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The impact of the COVID-19 pandemic on the Pharmaceutical Industry
The determining factors to ensure the profitability of the sector

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“You may have to fight a battle more than once to win it.”

— Margaret Thatcher

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Resumo

A pandemia COVID-19 afetou mundialmente todos os setores de atividade e a indústria farmacêutica e biotecnológica procurou desenvolver uma forma de prevenção ou cura. De imediato, especulou-se quanto estas empresas iriam beneficiar com a pandemia.

Esta dissertação incide, precisamente, sobre este tema. Através de uma análise quantitativa, usando uma regressão múltipla de dados em painel, considerando efeitos aleatórios e com uma amostra de 1622 empresas farmacêuticas e biotecnológicas globais entre o período de 2012 a 2021, exploraram-se os determinantes da rentabilidade destas empresas no contexto da pandemia. Por um lado, a relação entre fatores internos, como o tamanho da empresa, alavancagem financeira e investimentos em I&D foram analisados, por outro lado, estudou-se o impacto do COVID-19 na rentabilidade das empresas do setor.

Os resultados deste estudo sugerem que a rentabilidade deste setor é influenciada por fatores internos como o tamanho da empresa, alavancagem financeira e investimentos em I&D. O tamanho da empresa influencia positivamente, enquanto o nível de alavancagem financeira e os investimentos em I&D impactam negativamente a rentabilidade. Não obstante, contrariamente às previsões da sociedade e da comunicação social, a rentabilidade destas empresas parece ter sido negativamente afetada pela pandemia. Contudo, quanto ao desenvolvimento de vacinas ou tratamentos para o COVID-19, os resultados parecem demonstrar, como esperado, uma relação positiva entre o desenvolvimento destes produtos e a rentabilidade das empresas que os desenvolveram.

Esta dissertação vem ao encontro da necessidade de aprofundar a investigação sobre a rentabilidade deste setor de atividade e traz novas conclusões sobre os determinantes internos.

Palavras-Chave: Pandemia COVID-19, Determinantes da rentabilidade, Investimentos em I&D, Sector farmacêutico e biotecnológico

Classificação JEL: L25, L65, M41, O32

Abstract

The COVID-19 pandemic affected health and economies all over the world, and there was a tremendous effort within the pharmaceutical and biotechnology industry to pursue a prevention vaccine or cure. Soon enough, many began to query how much would this industry benefit from it.

That is precisely what this dissertation aims to investigate. By making a quantitative analysis, using linear panel regression with random effects estimation techniques and a dataset containing information on 1622 global pharmaceutical and biotechnology companies covering the period from 2012 to 2021, this research explores the determinants of profitability of these companies under the context of the COVID-19 pandemic. On one hand, the relationship between internal factors, such as firm size, leverage, and R&D investments, on the firm's profitability was investigated, and on the other hand, the impact of the COVID-19 pandemic on profitability was studied.

Findings from this research suggest that the profitability of this sector is influenced by the firm's size, leverage, and R&D expenses. Firm size has a positive impact, whereas leverage and R&D investments negatively influence profitability. Nevertheless, contrary to the media and public expectations, the pandemic seems to have negatively impacted these firms' performance. However, the results show a positive impact of the development of both vaccines and treatments for COVID-19 on these firms' profitability, meaning that, as anticipated, the development of COVID-19 products resulted in a profitability improvement.

This dissertation meets the call for further research and provides new conclusions on the determinant factors of the profitability of this sector.

Keywords: COVID-19 Pandemic, Profitability, Firm-specific Determinants, R&D investments, Pharmaceutical and Biotechnology sector

JEL Classification: L25, L65, M41, O32

Table of Contents

Introduction	1
Motivation	1
Research Problem	1
Research Objectives	3
Research Questions.....	4
Research Tools	5
Expected Results.....	5
Structure of the Dissertation.....	6
1. Literature Review.....	7
1.1. Firm’s Performance and Financial Analysis	7
1.2. Determinants of Profitability	12
1.3. Disruptive Events	15
2. Setting the Scene.....	18
3. Methodology	24
3.1. Research Design – Data and Sample	24
3.1.1. Sample size and time period.....	26
3.1.2. Dependent variable.....	28
3.1.3. Independent variables.....	30
3.2. Conceptual Framework.....	35
3.3. Data Analysis.....	37
4. Data Presentation and Results Discussion	39
4.1. Descriptive Statistics	39
4.2. Correlation Analysis	40
4.3. Regression Analysis	42
4.3.1. Assumptions and model validation	43
4.3.2. Results and discussion.....	44
Conclusion.....	49
References	55
Appendices	61
Appendix A Summarizing Table of the Literature Review.....	61
Appendix B Search strategy applied in <i>Refinitiv Eikon®</i> and <i>Microsoft Excel®</i>	64
Appendix C Correlation Matrix	65

Table of Figures

Figure 2.1. Profit evolution of COVID-19 vaccine makers. Source: Extracted from Buchholz (2021)	20
Figure 2.2. Expected patent losses between 2020 and 2030. Source: Extracted from Dunn (2021)	22
Figure 3.1. Initial Conceptual Framework	36
Figure 4.1. Final Conceptual Framework.....	43

Table of Tables

Table I. COVID-19 vaccines approved by WHO	34
Table II. COVID-19 treatments approved by WHO	34
Table III. Variables Analysed in the Model.....	35
Table IV. Summary of the Descriptive Statistics Results	39
Table V. Correlation Analysis between dependent and independent variables	40
Table VI. PLM Regression Results.....	45

Table of Equations

Equation 1. Return on Assets ratio equation.....	28
Equation 2. Return on Equity ratio equation	28
Equation 3. Earnings per Share ratio equation.....	29
Equation 4. Gross Profit Margin ratio equation.....	29
Equation 5. Debt-to-Equity ratio equation.....	32
Equation 6. Research and Development ratio equation	33
Equation 7. Model equation.....	36
Equation 8. Model equation (ROA and COVID-19 Vaccine)	44
Equation 9. Model equation (ROA and COVID-19 Treatment).....	44
Equation 10. Model equation (ROE and COVID-19 Vaccine)	45
Equation 11. Model equation (ROE and COVID-19 Treatment)	45

Abbreviation List

Abbreviation	Definition
B-G/W	Breusch-Godfrey/Wooldridge
CAPEX	Capital Expenditures
COVID-19	Corona Virus Disease 2019
CSR	Corporate Social Responsibility
C-TAP	COVID-19 Technology Access Pool
EPS	Earnings Per Share
FE	Fixed Effects
FY	Fiscal Year
GMM	Generalised Method of Moments
GPM	Gross Profit Margin
HC	Heteroskedasticity-Consistent
HLM	Hierarchical Linear Multilevel
IOV	Industry Organisation View
M&A	Mergers and acquisitions
OLS	Ordinary Least Squares
PLM	Linear Panel Regression
PM	Profit Margin
R&D	Research and Development
RBV	Resource Based View
RE	Random Effects
ROA	Return on Assets
ROE	Return on Equity
ROIC	Return on Invested Capital
ROS	Return on Sales
SUR	Seemingly Unrelated Regression
VIF	Variance Inflation Factor
WHO	World Health Organization

Introduction

Motivation

We are currently facing times of great instability and uncertainty. After the world went through the Coronavirus disease 2019 (COVID-19) pandemic and with a war with no end in sight in Europe, new challenges are looming, and only the most resilient companies, with better management and long-term planning, will be able to successfully overcome these challenges and ensure a sustainable future. Derived from my pharmaceutical background and given that the 2020 downturn was caused by a health pandemic I could not help but wonder how companies in the pharmaceutical industry would perform in the face of these challenges. Moreover, literature is scarce regarding the study of profitability in firms within this industry (Lim & Rokhim, 2021; Tušek et al., 2021). Therefore, the aim of this dissertation is to understand how much the changes that have been taking place are changing and challenging the stability, in terms of profit, of this sector.

Research Problem

The COVID-19 pandemic was a disruptive event that spread globally and affected the health, communities, ecosystems, and supply chains all over the world. In an attempt to contain the pandemic spread, governments urged to adopt strict procedures, such as social distancing, compulsory usage of protection masks, lockdowns, quarantines, and border closures which, lastly, led to an economic downturn around the world (Mansour et al., 2022).

When COVID-19 hit, all attention turned to the pharmaceutical industry and biotechnology companies, and soon enough, many began to question how much this industry would benefit from it. The financial and economic crisis triggered by the pandemic disrupted all sectors of the global economy by changing the internal and external environments of businesses, regardless of their size, activity, and location. However, at the beginning of 2020, articles across the media would state that, even though every economic sector was being affected, this pandemic was a “once-in-a-lifetime business opportunity” for the pharmaceutical industry, and this sector was not only surviving but profiting (Posner, 2020, as cited in Lerner, 2020, para. 2).

Certainly, when it comes to the pandemic, the pharmaceutical industry and biotechnology companies have played an important role. On one hand, they were part of the solution by producing products that tackled the pandemic (either by providing vaccines and treatments to immunize people and treat COVID-19 patients or by providing medical devices, such as masks,

to contain the spread). On the other hand, it is arguable that, by dealing with the pandemic, this industry also helped to bring the *old normal* and other economies back to life (Kuchler, 2022).

However, there is a literature void on how the profitability of these companies behaved after the impact of the pandemic.

Profitability is a very important indicator of the overall firm's performance. For years the central debate of several field researchers has been the determinant factors of a firm's performance (e.g., Bamiatzi et al., 2016; Goddard et al., 2005; Ketelhöhn & Quintanilla, 2012; McGahan & Porter, 2002; Short et al., 2007; Wang, 2023). According to Goddard et al. (2005), researchers of industrial economics, strategic management, and accounting and finance fields attempted to identify the determinant factors of variance in firm-level profitability by covering different types of research. Studies on the determinants that affect profitability can be divided mainly into the ones considering external or internal determinants. According to Bamiatzi et al. (2016), McGahan and Porter (2002), and Short et al. (2007) while industry- and country-specific factors are always present, firm-specific effects have a more significant impact on accounting profitability. Therefore, firm-specific factors, namely company size, age, liquidity, leverage, R&D intensity, and long-term financing, among others, have been extensively studied regarding their capacity to determine the firm's profitability (Lim & Rokhim, 2021). Ketelhöhn and Quintanilla (2012) stated that firm effects would account for between a third and a half of the total variance in a firm's profitability, and Yazdanfar (2013) also concluded that firm performance is largely affected by internal rather than external factors. Authors like Alarussi and Alhaderi (2018), Bayazidi et al. (2016), Flammer and Ioannou (2021), and Lim and Rokhim (2021) focused solely on the role of internal resources in a firm's performance.

Nonetheless, literature regarding the study of the firms' profitability determinants focused solely on the pharmaceutical and biotechnology industry sectors is scarce (Lim & Rokhim, 2021). Examples of these studies include Lim and Rokhim (2021) and Bayazidi et al. (2016) papers, which address, respectively, the factors affecting profitability, and the impact of Research and Development (R&D) and marketing costs on the profitability of pharmaceutical companies. Yet, the size of the database used may not be sufficiently big to draw proper conclusions, which raises limitations on the veracity of the conclusions made.

Moreover, some authors (e.g., Bamiatzi et al., 2016; Behbahaninia & Golbidi, 2022; Flammer & Ioannou, 2021) have also developed an interest in understanding and establishing how disruptive events, such as the Great Recession (2007-2009) and the recent COVID-19 crisis, may moderate the influence of the firm, industry, and country-specific factors in the

firm's performance. However, they have also identified the lack of empirical studies on this matter, and little is known in this regard.

From the information gathered, the present research study is one of the first attempts to analyse the impact of the COVID-19 pandemic on the performance of pharmaceutical and biotechnology companies. In 2020 there was an expectation, widely publicized by the media and regulatory bodies, that the pharmaceutical industry would profit enormously from the pandemic. However, this may not be the case since other factors should be considered, such as the impact of the rising costs of R&D on the profitability of these companies. Not all innovations produced by R&D investments get to be commercialized, but the expenses to develop these innovations impact the profitability of these companies. Therefore, scientific evidence is needed to be able to draw the appropriate conclusions.

What firm determinant factors regulate the profitability of this sector? In which way do R&D expenses impact the profitability of these companies? And what was effectively the impact of the COVID-19 pandemic on the Pharmaceutical and Biotechnology industry's profitability?

This study will focus, therefore, on studying the relationship of firm effects on profitability under adverse economic contexts due to disruptive events, in this case, the COVID-19 crisis, within the particular setting of the Pharmaceuticals & Medical Research Sector firms, including pharmaceutical and biotechnology companies. The subject of the problem that ought to be researched is the determinant factors that regulate the profitability of the pharmaceutical and biotechnology industry and, hence, the stability of one sector yet not particularly studied.

Research Objectives

The pharmaceutical industry is one of the most profitable industries in the world (Tottoc, 2021) despite its high proportion of R&D expenses. Indeed, pharmaceutical and biotechnology companies' profitability strategy is highly dependent on continuous innovation and improvement, meaning that a great part of their profits is redirected to invest in R&D. Nevertheless, when it comes to understanding the reasons underlying its profitability a lot of work has yet to be done (Lim & Rokhim, 2021).

This is even more imperious as unforeseen challenges, such as rising costs, lawsuits, new generic factories, loss of patents, and disruptive events (such as pandemics) may arise. If management is not prepared to deal with these challenges, it ultimately may lead to profitability losses and, therefore, risk the stability of the sector. Indeed, Lim and Rokhim (2021) argue that

a company's strategic direction is structured by understanding its profitability determinants. Managers need theoretical information to address these challenges, but there is a literature void on which factors are determinants for the profitability of the pharmaceutical and biotechnology industry so that the managers can make the best-informed decisions. The few articles regarding this industry had limitations in terms of sample size, so it has yet to consolidate conclusions (Bayazidi et al., 2016; Lim & Rokhim, 2021). Most of the research done on determinant factors of profitability has been conducted in other industries, namely, banking (e.g., Ahmad et al., 2020; Berger & Bouwman, 2013; Mansour et al., 2022) and manufacturing (e.g., Goddard et al., 2005; Yazdanfar, 2013) sectors. Moreover, the search for literature failed to retrieve any research studies (of peer-reviewed journals) on the impact of the pandemic on pharmaceutical and biotechnology companies' performance. Therefore, to tackle this gap in the literature, this dissertation aims to address the previously mentioned problems by identifying *what are the firm determinant factors that regulate the profitability of the sector of pharmaceutical and biotechnology companies and what impact the COVID-19 pandemic had on the profitability of these companies.*

The research objectives are, therefore, to develop a quantitative analysis to identify the firm determinant factors of profitability within this sector, so that internal users can make well-informed decisions, enhancing profitability and better preparing for the future. This is even more important in times of crisis where every measure is potentially risky for the end financial status of the company. Moreover, one of the purposes of this research is also to identify the impact of the development of COVID-19 products, both vaccines and treatments, on the profitability of these companies. Lastly, the aim of this dissertation is to contribute to the calling of past research studies on the profitability determinants in the pharmaceutical industry (Lim & Rokhim, 2021; Tušek et al., 2021).

Research Questions

In order to test the objectives stated previously and based on the literature's theoretical background, this dissertation is divided into two parts that will address each investigation question. The first part aims to identify *what firm-specific factors have an impact on the profitability of the pharmaceutical industry and biotechnology firms.* Whereas the second part will focus on *how the pandemic of COVID-19 has affected the profitability of these firms, and what impact the development of COVID-19 products has had on the profitability of these companies.*

Research Tools

Firstly, the search for literature consisted of going through several research papers of peer-reviewed journals using keywords related to the profitability of the pharmaceutical industry, and determinant factors of profitability available in online databases such as *Scopus*, *b-on platform*, *Google Scholar*, and *Proquest 5000*, as suggested by Major and Vieira (2017).

Secondly, to solve these research objectives, the research design incorporates a quantitative in-nature study. According to Ferreira and Sarmiento (2017) and Langfield-Smith (2006), quantitative accounting and strategy research consists of measuring a series of variables and conducting large-scale statistical analyses of associations. For this research, publicly available financial data from pharmaceutical and biotechnology companies was collected from the *Refinitiv Eikon®* database. The original database contains data from 3170 companies for the period of 2012 to 2022. Hence, the collected database had two dimensions, the company numerical identifier (cross-sectional) and the year (time-series). Data with both cross-sectional and time-series dimensions is regarded as panel data (longitudinal data). Therefore, a statistical analysis using a linear panel regression (PLM) was performed. Moreover, for the estimation of this model random estimation techniques were used and it was necessary to adjust for heteroskedasticity-consistent standard errors. Finally, descriptive and correlation analyses were also conducted, and the validation of the model and assumptions were performed.

Moreover, the data set collected contains detailed total revenues, Return on Assets (ROA), Return on Equity (ROE), Earnings per Share (EPS), Gross Margin (GPM), Headquarters Location, R&D Expenses, and the Number of Employees from the listed pharmaceutical industry and biotechnology companies. For the purpose of this dissertation, the profitability is going to be measured by ROA, ROE, EPS, and GPM ratios, while the independent variables to be studied are going to be firm-specific factors, such as firm size (as measured by the natural logarithm of total revenues), firm leverage (as measured by total-debt-to-total-equity), R&D investments (as measured by total-R&D-to-total-assets), and then a set of dummy variables to study the COVID-19 impact on the profitability of these companies.

Expected Results

It is expected that this dissertation will contribute with new evidence that can provide insights and clarity on the matter of the profitability determinants within the pharmaceutical industry. This research has the advantage of analysing and focusing on an industry not yet particularly studied, which can ultimately be of aid to management agents in making decisions (Lim &

Rokhim, 2021). Information about the firm's performance, especially its profitability, is of paramount importance for optimized decision-making in order to achieve sustainable growth and stability within the sector of activity.

Thus, it is expected that the profitability of this sector is going to be influenced by the firm's size, leverage, R&D expenses and the COVID-19 pandemic. Firm size and R&D are expected to positively influence the firm's profitability, whereas leverage is expected to have a negative impact on profitability. Moreover, the pandemic is expected to be a great profitability opportunity for pharmaceutical and biotechnology companies and, therefore, to positively impact these firms' performance.

Therefore, these results are expected to serve as a contribution to the literature already available regarding the study of firm-specific effects (e.g., Alarussi & Alhaderi, 2018; Bayazidi et al., 2016; Flammer & Ioannou, 2021; Lim & Rokhim, 2021) which could, ultimately, benefit internal users, such as managers, shareholders, and employees, by understanding the determinants of enhancing profitability. Moreover, it also contributes to the literature regarding the effects of disruptive events on a firm's profitability, in this case, the COVID-19 pandemic (e.g., Bamiatzi et al., 2016; Behbahaninia & Golbidi, 2022; Flammer & Ioannou, 2021). External users (investors, creditors, and tax authorities) may also benefit from this research to make the right investment decisions. Ultimately, this dissertation can be of aid to both internal and external users since these companies' business strategies can be analysed and compared with the factors that this study suggests that enhance profitability.

Structure of the Dissertation

This dissertation is constituted of four parts. First, a review of the literature available is carried out to support this dissertation. The field covered was profitability, namely, the factors that are determinants for profitability. Two research papers on the impact of R&D in pharmaceutical companies and the link between gross profitability and Pharmaceutical R&D spending were also included because of their relevance to the development of this thesis. Moreover, one conference paper on the profitability determinants of the global pharmaceutical and biotechnology companies during the COVID-19 pandemic was also integrated due to its relevance to the subject of this thesis. Then the contextualization of the project is presented followed by the methodology part where the collection and treatment of data are explained. Following, the presentation and discussion of the results is conducted. Finally, the concluding remarks of this dissertation are presented with suggestions for future research.

CHAPTER 1

Literature Review

For years the central debate of the economics, strategic management, accounting, and finance field researchers has been the determinant factors of a firm's performance (e.g., Bamiatzi et al., 2016; Goddard et al., 2005; Ketelhöhn & Quintanilla, 2012; McGahan & Porter, 2002; Short et al., 2007). The determinants of firms and industry have been central to this debate and recently the role of the country where the companies are inserted has also come of interest (Ketelhöhn & Quintanilla, 2012). McGahan and Porter (2002) contributed to a decisive moment in this line of work by performing a comprehensive study of the existing empirical literature on variance in accounting profitability. Their study greatly influenced the following research studies on the determinants of a firm's profitability by providing several suggestions to explore new approaches and techniques in this line of work.

Despite the numerous research studies done in this regard, the relevance of firm, industry, and country effects on a firm's profitability, particularly under adverse economic contexts due to disruptive events, remains unclear (Bamiatzi et al., 2016). Moreover, research studies on firms' profitability determinants focused on the pharmaceutical industry sector are scarce. A few examples of these studies include Lim and Rokhim (2021) and Bayazidi et al. (2016) papers, which address the factors affecting profitability, and the impact of Research and Development and marketing costs on the profitability of pharmaceutical companies, respectively. Despite that, and from the information gathered, there are not many attempts made, until now, to analyse the impact of the COVID-19 pandemic on the performance of pharmaceutical and biotechnology companies (Tušek et al., 2021).

This study will focus, therefore, on studying the relationship of firm effects on profitability under adverse economic contexts due to disruptive events, in this case, the COVID-19 crisis and in the particular setting of firms within the Pharmaceuticals & Medical Research Sector, including pharmaceutical and biotechnology companies.

1.1. Firm's Performance and Financial Analysis

To evaluate the overall firm's performance and, consequently, the long-term success of a firm it's inevitable not to reckon its profitability. How much are shareholders profiting, or not, with the investment made in the company's equity? And what are the earnings in the assets invested? Financial statements provide answers to these questions by disclosing all the information

needed to properly develop a financial analysis of a company (Damodaran, 2015). One can use this information by comparing the firm with itself, analysing its evolution through time using horizontal analysis, or by comparing the firm with other firms, within an industry, using a set of financial ratios (Berk & DeMarzo, 2017). The income statement provides the estimate of the profit of a company, in absolute amounts, by removing total expenses from the total revenues. Profitability is a financial ratio that expresses the relationship between profit and other selected items of the financial statements and is useful for analysing and comparing a firm's performance, for a given period of time (Weygandt et al., 2015). A firm has better performance the higher its profitability, which leads to economic growth, employment, innovation, and technological change. Moreover, the higher the profitability of a company the higher its ability to reward its owners with dividends distribution. Lastly, profitability is a good indicator, to both internal and external users, of management effectiveness and sound decision-making (Bayazidi et al., 2016).

Regarding how the profitability of a firm is measured, authors use, mainly, accounting measures such as Return on Assets, Return on Equity, Earnings per Share, and Gross Profit Margin. According to McGahan and Porter (2002), ROA is the most widely used measure of accounting profitability and the most used in the variance of profitability research literature. In fact, many researchers have used ROA as a proxy of profitability in their works (e.g., Bamiatzi et al., 2016; Bayazidi et al., 2016; Behbahaninia & Golbidi, 2022; Etienne et al., 2019; Flammer & Ioannou, 2021; Goddard et al., 2005; Guo, 2017; Karniouchina et al., 2013; Ketelhöhn & Quintanilla, 2012; Lim & Rokhim, 2021; Mauri & Michaels, 1998; McGahan & Porter, 2002; Short et al., 2007; Yazdanfar, 2013), since it depicts the actual position of the companies analysed. Moreover, some of these authors (e.g., Etienne et al., 2019; Flammer & Ioannou, 2021; Guo, 2017; Karniouchina et al., 2013; Mauri & Michaels, 1998; McGahan & Porter, 2002) computed ROA by dividing the operating income, instead of net income, to total assets, excluding any other expenses than the operating expenses. This is mainly done, as an attempt to disregard any other costs that are not part of the business operations. For instance, the acquisition of assets can come in the form of debt or equity, and have implications on taxes that are, then, incorporated into the net income. If the net income were to be used to compute ROA, this acquisition, even though not part of the operations, would have an influence on ROA.

Bamiatzi et al. (2016), Etienne et al. (2019) and Short et al. (2007) justified their choice of using ROA as a profitability measure to maintain consistency with prior research that used ROA as the profit ratio and, therefore, for reasons of comparison it would be better to use the same unit of measure over other accounting measures, such as ROE, for instance.

A great portion of research on profitability determinants has been done in the banking sector (e.g., Ahmad et al., 2020; Berger & Bouwman, 2013; Mansour et al., 2022). In a literature review of performance, profitability, and efficiency in the banking sector, performed by Ahmad et al. (2020), it was demonstrated that the most analysed financial ratio was ROA, followed by ROE and, on a smaller scale, net interest margin, non-performance loan and other ratios used to measure profitability on the banking sector. It is, therefore, reasonable to state that ROA is, indeed, the most used profitability measure even across industry sectors.

Even though most authors use ROA as a proxy measurement of profitability, other authors (e.g., Alarussi & Alhaderi, 2018; Lim & Rokhim, 2021) used other accounting measures, such as ROE and EPS, in their studies. According to Lim and Rokhim (2021), ROE has the benefit of depicting the firm's capability of producing profit from the invested equity in the company. Moreover, Stavropoulos et al. (2015) mentioned other accounting indicators that have been used, to a smaller extent, to evaluate a firm's performance: Profit Margin (PM), Return on Invested Capital (ROIC), and Return on Sales (ROS).

On the other hand, Mackey et al. (2017) argue that, even though most of the empirical literature on this matter uses accounting measures, such as ROA to measure a firm's performance, such measures have limitations, namely being subject to managerial manipulations (Palich et al., 2000, as cited in Mackey, 2017) and not accounting for risk (Hoskisson et al., 1993, as cited in Mackey, 2017). Moreover, ROA has the limitation of not being forward-looking capturing only short-term performance (e.g., Flammer & Ioannou, 2021; Mackey et al., 2017; Short et al., 2007). Furthermore, one limitation of using the operating income to compute ROA is that if any extraordinary expense, not considered on the operating income, reflects meaningful operational activity, the results reached may be distorted, since it is not reflected in the variance decomposition analysis (McGahan & Porter, 2002). Also, according to Short et al. (2007), relying only on ROA can understate the importance of the studied effects on a firm's profitability.

In fact, authors like Flammer and Ioannou (2021), Koku (2011), Mackey et al. (2017), and Short et al. (2007) have opted for other forms of measuring a firm's performance than accounting measures in their studies. Mackey et al. (2017) have used two market measures of firm value such as excess value and Tobin's Q, instead of ROA (accounting measure), whereas Koku (2011) used the stock market's reaction (excess market returns) as a proxy for profitability. According to Flammer and Ioannou (2021), accounting measures such as ROA focus on the short-term outcomes and do not reveal, to a certain extent, all the potential long-term value creation, making it necessary to use other measures to complement the research.

Therefore, they opted to use a profitability measure (ROA), complemented with other variables such as firm size, Tobin's Q, leverage, and liquidity, to evaluate the firm's performance in the long run. Short et al. (2007) also used, besides ROA, Tobin's Q (market measure) and Altman's Z (default risk or bankruptcy propensity measure) as measures of a firm's performance. Moreover, Bamiatzi et al. (2016) presented, in their work, the suggestion to explore alternative measures of a firm's performance as sales, growth, and Tobin's Q in an attempt to validate the conclusions achieved and to allow further comparisons of studies across countries.

For the purpose of this dissertation, ROA, ROE, EPS and GPM were used as profitability measurements, maximizing the potential of these measures, and minimizing their individual limitations. By using more than one indicator to measure profitability, this study is able to draw conclusions, regardless of the indicator used as a proxy, on the influence of the independent variables on these firms' profitability.

Over time, many were the authors that have been interested in understanding what might influence a firm's profitability and have, therefore, tried to establish which factors can have an impact on the profit rate of a company. One of the first empirical studies on determinants of corporate profitability can be traced back to 1951, when Joe Bain (1951) used a simple regression and correlation analysis to study the relation between profit rates and industry concentration, in American manufacturing companies, in the time period between 1936 and 1940. Bain was driven to study the subject due to, at the time, recent interest in the "potential association between the workability of competition and the structure of the industry" and, therefore, the need for empirical studies to support and formulate "specific hypotheses on the relations of market structure to market performance" (Bain, 1951, p. 293). Bain research's results showed that firms of higher seller concentration industries (industry-specific factor) have larger profit rates when compared to those of firms in industries of lower concentration. With his research, Bain also tried to show the relation between the size of the firm (firm-specific factor) and profitability, not having, however, obtained results that could corroborate this hypothesis. Moreover, Bain also made two very important final disclosures for the sake of future research. To begin with, Bain suggested that the time periods used may have had an impact on the results obtained and, hence, on the conclusions drawn. In turn, this led to the identification of the need to develop further studies with different time periods to corroborate conclusions. On the other hand, Bain has also indicated that other characteristics of market structure could be tested regarding their relation to profitability. A gap in the literature was, therefore, identified.

Since then, considerable research has been performed and studies can differ from each other regarding, mostly, the type of determinants studied, the theoretical perspective, the size of the sample, the time period and measurement units used, and the methodologies applied.

Between 1960 and 1980, most of the research literature on this field used cross-sectional regression analysis to link firm performance with industry-specific factors, some continuing the line of work initiated by Bain by studying the relationship between profit rate and seller concentration, and others by studying this relation with other characteristics, as suggested by Bain, such as advertising and R&D concentration (McGahan & Porter, 2002). However, in the 1980s and 1990s, limitations of these studies arose due to the author's assumptions that industry structure was responsible for the firm's performance, without taking into consideration other directions of causality (McGahan & Porter, 2002). A new approach to this line of work started, therefore, to develop as authors began to investigate the importance of year, industry, business-specific and corporate-parent effects on accounting profitability. However, despite the advances made with the new stream of literature, according to McGahan and Porter (2002), the breadth of data and statistical limitations were still leading to conflicting results and conclusions. Other authors (e.g., Guo, 2017) also noted that previous literature may have not captured adequately the interaction effects, random year effects, or nonlinear year effects due to the inability of the statistical approaches employed at the time, leading to biased interpretations and conclusions.

In 2002 we reached a turning point in the way this type of research is conducted with the McGahan and Porter (2002) comprehensive survey of the existing empirical literature on variance in accounting profitability. They made a remarkable difference by doing extensive work, using broader and less restrictive datasets and methods – the sample consisted of only publicly traded firms, covering different industries, in the American Economy. Thus, they demonstrated the relative importance of year, industry, corporate-parent and business-specific effects on profitability and how they differ across sectors of the economy. Moreover, they were able to attribute differences in the relative importance of external environments to the firm's performance in institutional settings, industry classifications, types of firms in the sample, empirical methods employed, and the period under study.

More recently there was also a great contribution to this line of work with the development of a systematic analysis conducted by Wang (2023) that showed a shift in the relative importance of determinants on performance variation between 1978 and 2019. This study has demonstrated that even though the industry's relative contributions to profitability seem to have mattered more than corporate effects between the 1970s and 1990s, throughout the 2000s and

2010s, the relative contributions have reversed, and corporate effects seem to be more important to explain business profitability.

1.2. Determinants of Profitability

The determinant factors of profitability studied may be segregated into three major categories: firm-specific factors (that comprise both business and corporate effects and may include, for instance, firm size, liquidity, solvency, or leverage of the firm), industry-specific factors (related, for example, to the industry structure, entry barriers, intensity competition, and the market concentration), and country-specific factors (namely the growth rate of GDP, inflation rates, interest rates, cyclical output, among others).

According to Goddard et al. (2005), researchers of different fields (industrial economics, strategic management, and accounting and finance) attempted to identify the determinant factors of variance in firm-level profitability by covering different types of research. Therefore, industrial economics has two main approaches, one emphasises industry characteristics (e.g., Bain, 1956; Porter, 1980) while the other emphasises the time-series behaviour of firm-level profitability (Goddard et al., 2005). The strategic management literature focused on the role of the internal resources of a firm (e.g., Alarussi & Alhaderi, 2018; Bayazidi et al., 2016; Flammer & Ioannou, 2021; Lim & Rokhim, 2021), and lastly, the accounting and finance literature concentrated on the random walk model as a descriptor of time-series movements in company earnings and profitability (Goddard et al., 2005).

Previous studies of the strategic management literature are divided in their conclusions regarding the relative importance attributed to firm and industry effects on the overall firm's profitability. The Resource-based View (RBV), formulated by Wernerfelt (1984) and Barney (1986), emphasizes the firm's internal resources (firm-specific factors) as the foundation for the firm's performance. Whereas the Industry Organisation View (IOV) main argument, formulated by Porter (1980), is that for performance maximization a firm must consider its external factors (industry-specific factors and external market organization). Nevertheless, Stavropoulos et al. (2015) suggested that it is frequently reasoned that both views complement each other. According to Stavropoulos et al. (2015), firms within the same external environment (location, industry, and year) have more similar performances.

Therefore, studies on the determinants that affect profitability can be divided into the ones considering external determinants (factors that reflect the market, business, or economic

environment) or internal determinants (factors affected by management decisions). For the purpose of this dissertation, this study will focus on the determinants of firm-level profitability.

Literature on the variance in accounting profitability has focused largely on industry effects (concentration, economies of scale, and entry and exit barriers), and to which extent industries, where companies compete, shape their profitability (e.g., Short et al., 2007; Stavropoulos et al., 2015). However, according to Bamiatzi et al. (2016), McGahan and Porter (2002), Short et al. (2007), and Stavropoulos et al. (2015) while industry- and country-specific factors are always present, firm-specific effects have a more significant impact on accounting profitability. Therefore, firm-specific factors, namely company size, age, liquidity, leverage, R&D intensity, and long-term financing, among others, have been extensively studied regarding their capacity to determine the firm's profitability (Lim & Rokhim, 2021). Ketelhöhn and Quintanilla (2012) stated that firm effects would account for between a third and a half of the total variance in a firm's profitability, and Yazdanfar (2013) and Wang (2023) also concluded that firm performance is largely affected by internal rather than external factors.

On the other hand, Stavropoulos et al. (2015) focused their research on data sparseness in studies of variance in accounting profitability. They argued that data sparseness could be a driver of misleading results by overestimating the effects of the variables studied on profitability (estimations using a smaller number of firms per industry showed a greater impact of the industry effects on profitability). They also identified that early literature studies focused on industry effects and used samples with, on average, two companies per industry. Even though Stavropoulos et al. (2015) only studied industry effects they expect that this limitation is even more substantial in studies that include more complex determinants and interactions (e.g., location, regional cluster, life cycle, and year effects), since it results in a smaller number of observations per group. Thus, according to Stavropoulos et al. (2015) and Yazdanfar (2013), variance in profitability research literature linked to external factors, such as industry, location, and year effects, remains ambiguous, and conclusions are still conflicted on the importance of external factors on profitability. Finally, Stavropoulos et al. (2015) concluded that even though studies appointed 20% to industry effects on firms' profitability, the "real" value may be lower than 8,9%. Therefore, this study suggests that firm effects on accounting profitability are even more important than previously thought (Stavropoulos et al., 2015). Taking these arguments into consideration, the firm-specific determinants of profitability within the pharmaceutical and biotechnology industry companies were studied, and the following question was formulated:

Q1. What firm-specific factors have an impact on the profitability of pharmaceutical industry and biotechnology firms?

Some related studies have analysed these aspects in different countries and different sectors such as in the USA banking sector (e.g., Berger & Bouwman, 2013), in Sweden in non-financial micro firms operating in four industry sectors (e.g., Yazdanfar, 2013), and in Malaysia on public listed firms (e.g., Alarussi & Alhaderi, 2018), among others. According to Lim and Rokhim (2021), most of these studies are empirical by studying the relationship between profitability and the determinant factors within the extent of one particular country or sector of activity. For the purpose of this study, only the sector of the pharmaceutical industry and biotechnology companies is going to be studied but not restricting the companies' headquarters to a single country or location. In this way, this study aims to understand the profitability determinants of these firms regardless of their location.

Flammer and Ioannou (2021) conducted an exploratory study on the relationship between performance results and changes in strategic investments (firm-specific factors: workforce, capital expenditures, R&D, and Corporate Social Responsibility) made by companies during the financial crisis of 2007-2009. Evidence from this exploratory study suggested that firms that sustained their R&D expenses, concomitantly with the maintenance of Corporate Social Responsibility (CSR) and reduction of Capital Expenditures (CAPEX) and Workforce expenses, during the 2008 crisis were able to sustain their competitiveness during the crisis and performed better after the crisis (higher ROA). According to this study, in industries where innovation is of greater strategic importance to competitiveness, companies refrain from reducing their R&D investments. Also, according to Brown and Kimbrough (2011), the impact of R&D is greater for industries where patents are most effective in protecting R&D (as in the case of pharmaceutical industry companies). Moreover, Short et al. (2007) pointed out that companies that have higher investments in R&D are viewed as companies that have the capability to innovate and pursue new opportunities. Behbahania and Golbidi (2022) also investigated whether R&D activities reduce the performance damage caused by a disruptive event, in their case the COVID-19 pandemic. Their results showed that firms that have more R&D activities performed better than other companies during the period of the COVID-19 crisis and were able to better manage times of adversity. They suggested that this is because companies that invest in R&D are more likely to be able to launch new products to meet the market demand. Therefore, they suggested that investments in R&D should not be stopped or decreased in times of difficulty, since R&D activities are key to improving the situation of companies even in periods of crisis and lack of resources. Therefore, one of the firm-specific factors to be studied in this dissertation will be the R&D expenses impact on profitability. In terms of research literature, in the pharmaceutical industry field of research, the main topic

studied is R&D investments, while other profitability factors, such as financial ratios, have been put aside for this line of work (Lim & Rokhim, 2021). To maintain consistency with past literature and to shed some new conclusions on the profitability of the pharmaceutical industry companies, other firm-specific factors such as firm size (e.g., Alarussi & Alhaderi, 2018; Bain, 1951; Flammer & Ioannou, 2021; Goddard et al., 2005; Lim & Rokhim, 2021; Short et al., 2007; Yazdanfar, 2013) and financial determinants such as firm leverage (e.g., Alarussi & Alhaderi, 2018; Bayazidi et al., 2016; Flammer & Ioannou, 2021; Goddard et al., 2005) are also subject of the study.

As previously mentioned, most studies in this field dominantly focus on a specific industry and specific factors affecting profitability. Nevertheless, one should not view these factors as independent since there may be joint effects between factors on profitability. Guo (2017) findings confirmed that the corporation and industry effects were rather inter-correlated than independent. In fact, studies in this field have become, with time, more complex adding several different dimensions, such as industry-by-country, industry-by-subregion, and industry-by-year effects (industry- and country-specific factors) (Stavropoulos et al., 2015). Authors such as Bamiatzi et al. (2016) have also started to investigate the interaction between these factors, but the conclusions of different research are still very conflicted.

1.3. Disruptive Events

Some authors (e.g., Bamiatzi et al., 2016; Behbahaninia & Golbidi, 2022; Flammer & Ioannou, 2021) have also developed an interest in understanding and establishing how disruptive events, that have the power to change economic cycles, moderate the influence of the firm, industry, and country-specific factors in the firm's performance.

Flammer and Ioannou (2021) identified that financial market collapses such as the Great Depression (1929), the Great Recession (2007-2009) and the recent COVID-19 crisis destroyed the financing forms of many companies due to the collapse of the financial sector. Thus, such extreme events may have an impact on the firm's external and internal environment and, consequently, on firm-level decision making and companies may have to rethink their strategy to ensure sustainability. However, little is known in this regard. In fact, Bamiatzi et al. (2016) and Flammer and Ioannou (2021), identified the lack of empirical studies on this matter. Agarwal et al. (2009) (as cited in Flammer & Ioannou, 2021) highlighted the lack of literature relating firms' adoptions to extreme events such as a financial crisis. Bamiatzi et al. (2016, p. 1451) also stated that until 2016 none of the studies made on the determinant factors of

profitability “made an explicit distinction between economic expansion and recession”, identifying, therefore, a gap in the literature.

Bamiatzi et al. (2016), Behbahaninia and Golbidi (2022), and Flammer and Ioannou (2021) have tried to bridge the gap by studying the determinant factors of profitability and the influence of economic cycle shifts on the results.

Bamiatzi et al. (2016) studied the relationship between firm, industry, and country-specific factors with profitability, in a period that covered 2005 and 2011, comprehending two different economic cycles, economic munificence (2005-2007) and economic recession (2008-2011). Findings from the Bamiatzi et al. (2016) study suggested that, indeed, the economic environment is decisive in determining the role of the firm-, industry- and country-specific factors on firm profitability. The results showed that firm-specific factors are amplified during recessionary periods in both developed and emerging economies and that under such periods, strategic choices and capabilities gain major importance in determining firm profitability. Furthermore, the results also demonstrate that with a recession, the impact of industry-specific factors weakens, showing that in times of crisis industry participants will focus on conducting firm-specific strategic responses. This corroborates with Short et al. (2007) view that managers should focus on firm-level concerns since research shows a higher impact of firm effects on profitability. It also evidenced the importance of the country-industry interaction effects on firm profitability, meaning that the way each country uses its resources to develop industrial competencies is of major importance for firm performance. With this study, Bamiatzi et al. (2016) concluded that a firm’s success is mostly related to its own strategies and resources which was made even more evident in times of economic distress, such as recessions. Moreover, in such periods the industry- and country-specific factors that impact the firm’s profitability are reduced.

Conversely, Behbahaninia and Golbidi (2022) studied the relationship between firm-specific factors and the impact of the COVID-19 pandemic on the firm’s profitability, covering the period of 2019 to 2020. Their results suggested that COVID-19 had a negative impact on the profitability of the companies studied. The R&D activities studied as a firm-specific determinant, showed a positive relationship with profitability, meaning that companies that invest in R&D generate better performances than those which do not invest as much. Moreover, one important aspect of this research is that they have used one cross-variable of COVID-19 and R&D, portraying the interactive effect of COVID-19 and R&D investments on the firm’s profitability. The results of this variable showed a positive influence on profitability, regardless of the dependent variable used (ROA, ROE or revenue growth). These results seem to suggest

that the R&D investments were able to prevent the negative impact of the COVID-19 crisis on the performance of the companies in the study. Therefore, they have concluded that these activities are, in fact, the key to improving the situation of companies even in a period of crisis and lack of resources.

Taking into account the research objectives of this dissertation, the focus of this research study will also be on studying the impact of disruptive events, in this case, the COVID-19 crisis, on the profitability of the pharmaceutical and biotechnology industry companies. Therefore, the following research question was structured as shown:

Q2. How has the pandemic of COVID-19 affected the profitability of the pharmaceutical industry and biotechnology firms? And has the development of COVID-19 products had an impact on the profitability of these companies?

To summarize the most relevant research studies reviewed, a table with the most important aspects to take into consideration while analysing this study was created and can be seen in Appendix A.

CHAPTER 2

Setting the Scene

The pharmaceutical and biotechnology companies are responsible for discovering, developing, producing, and delivering to the market medicines with the aim of curing diseases, vaccinating the population, or alleviating symptoms. The difference between pharmaceutical companies and biotechnology companies is not always easy to explain and they are usually treated indistinctly and as an all. However, typically, biotechnology firms research and develop new products in association with large pharmaceutical firms that provide production and distribution logistics.

According to the data available in Statista, pharma revenues worldwide totalled 1,48 trillion U.S. dollars in 2022, a small increase from 2021 when the market was valued at 1,42 trillion U.S. dollars (Mikulic, 2023). In 2021, only two other industries, Software (System and Application) and Computer Peripherals outperformed the pharmaceutical industry in terms of profitability (Tottoc, 2021). In fact, if we take into consideration that the pharmaceutical industry is labelled for its highly-priced products it is not surprising to see this industry included in the top three of the 15 most profitable industries in the world in 2021 (Tottoc, 2021). According to the data available in Yahoo Finance, the drugs and pharmaceuticals industry has attained, in 2021, a gross profit of \$643.2 billion and a 17.06% return on capital (Tottoc, 2021).

Nevertheless, there is a unique difference that sets apart this industry from others. To maintain its high profits, the pharmaceutical industry is extremely dependent on the development of new medicines, with its R&D expenses reaching at least 20% of its sales revenue, which is far higher than other industries (Bayazidi et al., 2016; Mikulic, 2023; Schuhmacher et al., 2021). In fact, this is one of the reasons appointed to the highly-priced innovative drugs (Mikulic, 2023). Moreover, it is important to note that there is evidence that the higher the R&D investment the higher the probability of success in developing new molecular entities (Schuhmacher et al., 2021). According to Kanapeckaite (2021), the failure rate of new medicines discovery, for either not being safe or cost-effective, is as high as 96%. Therefore, in theory, only with a high investment in the development of new medicines can these companies maintain their sustainability, and, in fact, between 1999 and 2018 there is evidence of an increase in investment in R&D of the 14 leading pharmaceutical companies studied by Schuhmacher et al. (2021).

In 2020 the COVID-19 pandemic was declared, and the pharmaceutical industry played a crucial role in its resolution. However, there was some controversy regarding the interest of these companies and the maximization of profits. World Health Organization (WHO) recognized the risk of big pharma pursuing profits over people's needs with the consequence of poorer countries finding it harder to access COVID-19 vaccines. To overcome this situation and to ensure that all people, regardless of their country of origin or their socio-economic situation, could have access to these preventive vaccines, WHO created, in May 2020, the COVID-19 Technology Access Pool (C-TAP) to "facilitate faster equitable and affordable access to COVID-19 health products" (*WHO COVID-19 Technology Access Pool*, n.d., para. 1). At the beginning of 2022, two years after the start of the pandemic, articles of opinion stated that it was a mistake to put the big pharma companies in charge of the global vaccine rollout (Dearden, 2022). Pfizer, for instance, developed, what would have become, the most distributed COVID-19 vaccine globally, making it the "most lucrative medicine in any given year in history" (Dearden, 2022, para. 1). However, since pharmaceutical companies had the power to set the terms and prioritize the sales, the global distribution of vaccines was, allegedly, unevenly made which, in turn, created access inequalities. Pfizer was accused of selling the vast majority of its vaccines to the world's richest countries to keep its profits high disregarding sharing their know-how in the C-TAP. Moreover, even though a temporary lifting of patents was expected, which would make the production of these vaccines in poorer countries more feasible, such a thing did not happen. In fact, with the recommendation of WHO, the European Parliament approved the demand for lifting the patents, but EU leaders failed to act on it and, instead, reinforced the donations of vaccines to the poorer nations (Rahman, 2022). Moreover, in 2021 a "massive pharma lobby spending in Washington DC as part of the effort to block generic COVID-19 vaccines" was reported (Corporate Europe Observatory, 2021, para. 6). It was also suggested that this industry was spending an "enormous amount of money on influencing EU decision-making" (Corporate Europe Observatory, 2021, para. 6). According to public health movements, the remotion of these protection patents was the only way to terminate the "high prices and the shortage of vaccines and treatments" by ending the "production monopoly, conferred for 20 years patents" (Rahman, 2022, para. 9). However, in EU Commission President Ursula von der Leyen's point of view patents "don't tell the whole story", since vaccine production requires "know-how, technology, skilled personnel, infrastructure. You don't get there by simply waving IP [Intellectual Property] rights"¹. According to Anna

¹ <https://twitter.com/vonderleyen/status/1402593753165185024>

Marriott, policy lead for the People's Vaccine Alliance, in the end, taxpayers have paid three times for the COVID-19 vaccines: "First with billions for research, then with bloated prices draining public funds, and finally because they're [big pharma] paying little in taxes" (Peigné, 2021, para. 11). After all this scrutiny, in 2022 EU tried to make amends by launching several initiatives to boost the production of pharmaceuticals in poorer nations (Reuters, 2022).

Currently, the pharmaceutical industry is growing due to the increased demand for healthcare. In 2021, global pharmaceutical sales grew by 7.7%, and global healthcare spending, between 2020 and 2025, is expected to increase at an annual rate of 4.8% (AstraZeneca, 2021). Furthermore, the AstraZeneca 2021 Annual Report addressed the shift from an almost exclusive focus on treatment towards a focus on prevention and early intervention. The COVID-19 pandemic was the trigger that made this change possible by accelerating healthcare innovation (AstraZeneca, 2021).

COVID-19 was indeed a game-changer. Up until 2020, Johnson & Johnson was the world's largest biopharma company with \$82.6 billion in revenues but with the COVID-19 pandemic, it was estimated that Pfizer would reach and, even, surpass the \$100 billion mark in 2022, an unthinkable value up until now (Liu, 2021; Sagonowsky, 2021). This expectation materialized, according to the latest financial statements of 2022, Pfizer's annual revenue for 2022 was \$100.33 billion, a 23,43% increase from 2021 (Pfizer, 2023). Moreover, most COVID-19 vaccine makers (Johnson & Johnson, Pfizer, AstraZeneca, Moderna, and BioNTech) saw their profits increase greatly since the COVID-19 vaccine rollout (see Figure 2.1) (Buchholz, 2021). Only AstraZeneca recorded a loss in profits in the first three quarters, which they explained by an increase in costs of R&D, and, on the other hand, the COVID-19 vaccine was sold at the price of cost (Buchholz, 2021).

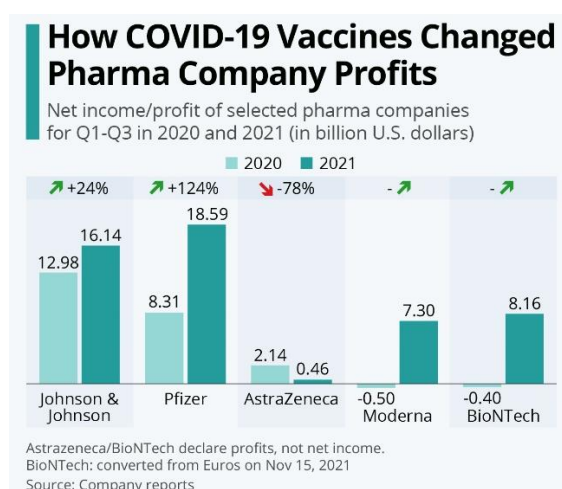


Figure 2.1. Profit evolution of COVID-19 vaccine makers. Source: Extracted from Buchholz (2021)

Following this line of events, room for global controversy on the market exclusivity detained by big pharma, protected by intellectual property rights and patents, was made, and we are facing, currently, a period of great scepticism over the never-ending growing profits of the pharmaceutical industry. This growing scrutiny presents an opportunity to question the ways this industry is running a business (Milani & Duffy, 2019b). Scherer (2001) admitted that since the 1950's the main argument that this industry uses to sustain the high profits is that these profits are redirected to finance the R&D investments. This study's findings seem to indicate a pattern of a "virtuous rent-seeking" model, since as profit opportunities arise, companies tend to compete to exploit those opportunities by increasing R&D investments until the increases in costs dissipate the returns generated (Scherer, 2001, p. 220). According to Milani and Duffy, the need for high medicine prices to fund R&D expenses is a false narrative to cover the reality of pharmaceuticals putting shareholders' wealth first (Milani & Duffy, 2019a). Adding to the series of mergers that consolidated the pharmaceutical industry, we are now dealing, in their opinion, with a much stronger and more influential industry (Milani & Duffy, 2019a).

Furthermore, according to Short et al. (2007), the pharmaceutical industry benefits from the high difficulty entering the industry and the relatively polite competition, making their profitability strong for decades. The sources of such persistent and "above-normal" profitability in this industry were, according to Comanor (1986, as cited in Roberts, 1999, p. 659), subject to great academic debate. Parallel to this, with the development of COVID-19 vaccines, much has been discussed about protection patents (Queiroz, 2022). The pharmaceutical industry, being highly dependent on the discovery of new innovative medicines to have a competitive advantage and maintain high margins, is facing, nowadays, serious challenges due to the loss of high-value patents. According to Roberts (1999), even though profits from each innovation tend to drop with time, innovation ensures that the firm maintains a high-performance position. When a branded medicine loses its protective patent and generic competition takes place, pricing power and sales start to drop (Bayazidi et al., 2016). In the past 15 years, the industry has seen some great patent losses. Between 2007 and 2017, the 10 biggest medicines losing patent protection set a record of \$915 billion in lifetime sales losses (Sagonowsky, 2017). The future does not look bright either. In this next decade (2020-2030) the top four of the industry's best-selling medicines in 2020 (Humira, Keytruda, Revlimid, and Eliquis) are expected to also lose their protective patents (cf. Figure 2.2).

Major drugs set to lose patents in next decade

The 15 top selling drugs facing expirations pulled in more than \$100 billion in sales last year.

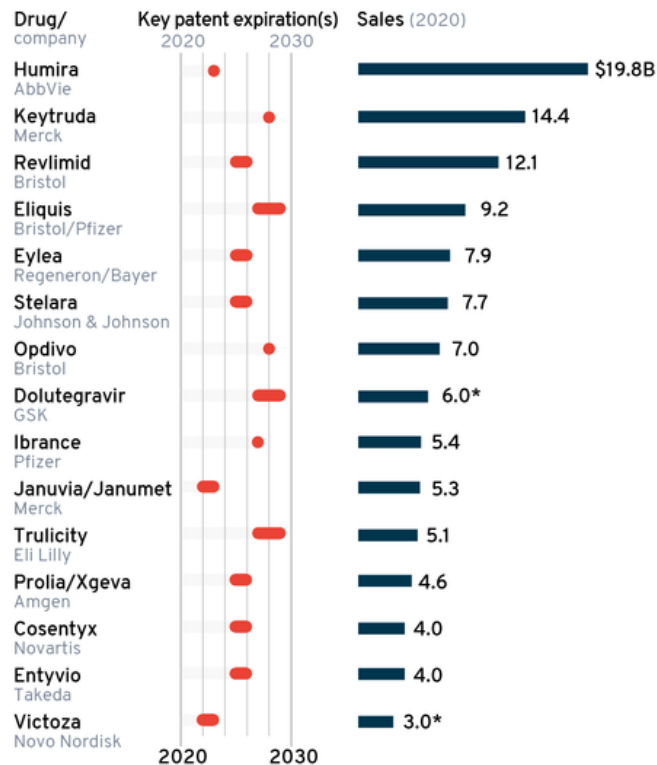


Figure 2.2. Expected patent losses between 2020 and 2030. Source: Extracted from Dunn (2021)

To overcome this ever-greater challenge big pharma turned to mergers and acquisitions (M&A) of other companies as a way of creating synergies and maintaining sustainability. It is starting to become evident that the line of action and expansion of this industry involves acquiring smaller companies with new, already developed, products to monopolize their intellectual property, by creating new patents and, consequently, stay competitive and maximize the price of the drugs released onto the market (Fontanella-Khan & Smyth, 2022; Jung et al., 2019). In fact, according to Schuhmacher et al. (2021), the majority of new molecular entities approved from 1999 to 2018 were sourced through M&A (41%) and drug licensing (19%), evidencing the growing dependency of these companies on external sources of innovation (when compared to proprietary research which contributed with 40% of the new molecular entities approved). Moreover, usually, M&A and collaborative partnerships have been established between pharmaceutical companies and biotechnology companies (Schuhmacher et al., 2021). Are recent examples, the purchases of Biohaven Pharmaceuticals, Arena Pharmaceuticals and Global Blood Pharmaceuticals by Pfizer, using the generated profits of the COVID-19 vaccine, or Amgen purchasing ChemoCentryx, Gilead acquiring MiroBio, the AstraZeneca acquisition of Alexia, and so on.

Finally, the pharmaceutical industry has a lot of features that make it unique when compared to other industries. To fully understand this industry, one should consider the fact that, producing health products is a heavily regulated field, and it uses substantial government funds (Milani & Duffy, 2019b). Thus, corporate financialization, shareholder primacy, market power, and tax law can have a huge impact on the business strategy and how the business is run. Some consider that the industry is putting excess profits for shareholders and CEOs ahead of affordable medicines and better outcomes for the people. According to Milani and Duffy (2019), today's problems in the pharmaceutical industry reside in the high prices, low investment, misaligned incentives and escalating shareholder dividends, which should be analysed for the sake of public health.

CHAPTER 3

Methodology

This section will proceed to explain the approach chosen to study the subject. First, the approach is detailed, followed by the data collection details and finally, the conceptual framework of this study and data analysis are presented.

This dissertation's research objectives are to study what determinant factors regulate the profitability of the pharmaceutical and biotechnology sector and to identify the impact of the COVID-19 pandemic on the profitability of this industry. To solve these research objectives, and based on the literature's theoretical background, a quantitative in-nature study should be performed by developing a conceptual framework and questions that can be demonstrated (Oliveira et al., 2017). Therefore, the following research questions were settled:

Q1. What firm-specific factors have an impact on the profitability of pharmaceutical industry and biotechnology firms?

Q2. How has the pandemic of COVID-19 affected the profitability of the pharmaceutical industry and biotechnology firms? And has the development of COVID-19 products had an impact on the profitability of these companies?

According to Ferreira and Sarmento (2017) and Langfield-Smith (2006), quantitative accounting and strategy research consists of measuring a series of variables and conducting large-scale statistical analyses of associations, through several stages, namely, the definition of the problem, setting the objectives of the research, data collection and validation, the models' construction, and the validation and presentation of the results. Therefore, to answer this type of research questions one should perform a statistical analysis.

3.1. Research Design – Data and Sample

The initial literature search consisted of going through several research papers resulting from keywords related to the profitability of the pharmaceutical industry available in online databases such as *Scopus*, *b-on platform*, and *Google Scholar*. Therefore, keywords such as “profitability”, “pharmaceutical industry”, “determinant factors”, and “literature review” were used. Since the literature available on the pharmaceutical industry mostly comprises studies related to the operational and R&D fields, some filters to limit the research papers had to be used. Thus, the research was limited to open-access papers and all studies that were not related

to the management field were excluded. This search did not result in any viable research papers to serve as a foundation for this dissertation.

Therefore, the search for literature took a shift and the retrieving of research papers was filtered to those that focused on the determinant factors of profitability, published after the year 2000, in peer-reviewed journals available in online databases such as *Proquest 5000*, *Scopus*, *b-on platform* and *Google Scholar*, as suggested by Major and Vieira (2017). Keywords used for this search were “profitability”, “determinant factors”, and “variance in profitability”. Only research papers and literature reviews of academic journals of management or finance areas were included. This search resulted in 41 articles, whose abstracts were analysed, and from which 30 were used in this research study and review of the literature. One conference paper was also used due to its pertinence to the area of study of this dissertation.

Furthermore, publicly available financial data from the pharmaceutical industry and biotechnology companies was collected from the *Refinitiv Eikon®* database. *Eikon®* is a financial analysis platform that provides access to real-time accounting information of publicly listed companies globally.

The sample collected from the *Refinitiv Eikon®* platform consisted of companies in the “Pharmaceuticals & Medical Research” sector, including both pharmaceutical and biotechnology companies. The sample will be limited to this specific sector, a more precise classification than industry groups, in an attempt to assess and infer correct conclusions regarding the relationship between the firm’s environment and its performance (Stavropoulos et al., 2015). Additionally, the data included in the analysis is retrieved from the financial annual statements of the companies, namely the balance sheet and income statement, where the unit of measure is in millions of US dollars.

The data set collected contains detailed total revenues, ROA, ROE, EPS, GPM, Headquarters Location, R&D Expenses, and the Number of Employees from the listed pharmaceutical industry and biotechnology companies that occurred in the period between 2012 and 2022. The original database contains data from 3170 companies in the pharmaceutical industry and biotechnology sectors. From the Data collected ratios to measure both Firm Size and R&D investment dimensions were computed. A total of 4 dependent variables (ROA, ROE, EPS and GPM) and 7 independent variables (*Firm Size* – Log Assets, Log Revenues, Log Employees; *Firm’s Leverage* – Total debt to total assets, Total Debt to total equity; *Firm Location* – Dummy variable of the firm’s headquarters location; *R&D Expenses* – R&D to total Revenues, R&D to total Assets; *COVID-19* – dummy variable if the data is related to the COVID-19 pandemic years, dummy variable of the development of vaccines, and dummy

variable of the development of treatments) were used in the preliminary panel analysis to study the model. From the results of the preliminary analyses, it was concluded that not all variables were appropriate to be used, and only ROA and ROE were used as dependent variables, i.e., profitability, while Firm Size, Firm Leverage, R&D investments and the COVID-19 dummy variables were used as independent variables to study the model.

3.1.1. Sample size and time period

Numerous empirical studies have endeavoured to clearly identify the determinants of a firm's profitability, focusing on different industry sectors, and several periods of time. Nevertheless, despite all the efforts made to reach stronger and empirical conclusions on the determinant factors of profitability, Yazdanfar (2013) suggested that all the dispersion of analysis performed so far, with different theoretical approaches, different sample types and sizes (usually small samples), different measures of variables and different methodologies applied, make it extremely difficult to make direct comparisons of results and, consequently, draw accurate and generalized conclusions.

For this study, the database collected contained data from 3170 companies in the pharmaceutical industry and biotechnology sectors, through the time span of 2012 and 2022. After the data was critically and thoroughly examined, it was understood that not many companies had made their financial reports of 2022 available, at the time of the data collection, which could, ultimately, jeopardize the significance of the results of the analysis performed. Therefore, this study filtered a period of 10 years between 2012 and 2021. Additionally, selection criteria were applied to the original sample and, to avoid including non-operational firms in the sample, only companies that had their last financial statement available in the year 2021 and revenues larger than 0 in that year were used in this research. The criteria used to process and filter the database are further described in a Boolean Search Table (Appendix B).

Hence, the database was limited to 1622 companies. Moreover, while performing the regression analysis, firms for which there were missing data or abnormal observations on the dependent variables were removed from the sample, which limited the number of companies even further. Descriptive statistics for the full set of variables included are presented in Table IV.

Stavropoulos et al. (2015) stated that even though past literature may have overestimated the relationship of factors to a firm's profitability due to the sparseness of data, little attention has been paid to the required sample size that leads to robust results in the matter. Therefore, although there are no conclusive studies regarding the size of the sample, some authors (e.g.,

McGahan & Porter, 2002; Stavropoulos et al., 2015) seem to find bigger samples better to produce more significant and meaningful results. Thus, the sample collected seems sufficient to contribute with robust results to this study, especially when compared directly to the studies made within this industry that have used 10 pharmaceutical-listed companies in Indonesia (e.g., Lim & Rokhim, 2021), 27 pharmaceutical companies of Tehran Stock Exchange (e.g., Bayazidi et al., 2016), and 52 global pharmaceutical companies (e.g., Tušek et al. 2021). Moreover, the size of the data used is also bigger than other studies performed on the profitability determinants matter, such as Alarussi and Alhaderi (2018) which used 120 listed companies, Flammer and Ioannou (2021) with 670 publicly traded companies, and Short et al. (2007) with 1165 single-business firms. Yet, when compared with other studies (e.g., Bamiatzi et al., 2016; Goddard et al., 2005; McGahan & Porter, 2002; Yazdanfar, 2013), the size of the sample may still feel small.

Regarding the time periods used in this line of work, they vary vastly according to the type of study performed. However, one should take into consideration that results can be distorted if the period selected contains the occurrence of any unusual events. For instance, unusual macroeconomic conditions in the 1970s might have affected industry, corporate-parent, and firm-specific performance and, hence, the results obtained from studies that did not cover a big enough period that could control for these unusual conditions may be distorted (Schmalensee's, 1985 and Rumelt's, 1991, as cited in McGahan & Porter, 2002). Furthermore, according to McGahan and Porter (2002), an extended time period allows for the identification of effects that are truly stable over a long period and span across several phases of the business and economic cycles.

Analysing studies performed under disruptive events in the economy (e.g., Bamiatzi et al., 2016; Behbahaninia & Golbidi, 2022; Flammer & Ioannou, 2021) the time periods covered were of 1, 3 and 5 years. According to the article of Keats and Hitt (1988) (as cited in Short et al., 2007), a robust statistical analysis should contain a time series of 5 years of performance data to provide a stable measure of a firm's profitability. Other authors such as Short et al. (2007) suggested that a time frame bigger than the 7-year period (like they used) could contribute with additional knowledge on the hypothesis they studied. Since this study aims to analyse how the COVID-19 pandemic influenced the profitability of the pharmaceutical industry, the time frame selected had to cover a pre-COVID period and a post-COVID period of economic recession after the COVID-19 crisis hit in 2020. Thus, the sample selected for this study expanded the recommended time period from 5 years to 10 years (2012-2021) with the aim of contributing to more robust results. Indeed, Bayazidi et al. (2016) and McGahan and

Porter (2002), also used more extensive time periods, of 13 years and 14 years, respectively, to proceed with their analysis.

3.1.2. Dependent variable

Since this study ought to analyse the performance of pharmaceutical and biotechnology firms the dependent variable to evaluate is going to be profitability.

Profitability, unlike profit, is a relative amount, meaning that, by being a ratio between the profit and other selected items of the financial statements, it, in turn, serves as a measurement of the efficiency of a company for a given period of time. Therefore, although a company may, in absolute terms, generate profit it does not necessarily mean that the company itself is profitable.

To analyse the accounting profitability of pharmaceutical industry firms, accounting measures should be used. Thus, accounting profitability ratios are used to assess the company's ability to generate value, either relative to its revenue, operating costs, the company's assets (Return on Assets), or the shareholder's equity (Return on Equity). Moreover, EPS and Gross Profit Margin (%) are useful as accounting ratios of profitability as well. The higher these indicators' value the higher the profitability of the firm.

Return on Assets measures the relationship between the company's end income and its book value of total assets (see Equation 1). It provides an idea of how effectively the assets of a company are being used to generate profit (Lim & Rokhim, 2021). Since ROA depends on the assets of a company it can vary greatly among industries with different asset bases.

$$ROA = \frac{Net\ Income}{Total\ Assets} \times 100 \quad (1)$$

Return on Equity analyses the return on profits received for each monetary unit invested in the company's stock (see Equation 2). It, therefore, provides an interest rate of the shareholder's capital made available to the company (Alarussi & Alhaderi, 2018; Lim & Rokhim, 2021).

$$ROE = \frac{Net\ Income}{Average\ Shareholder's\ Equity} \times 100 \quad (2)$$

Although both measures analyse the ability of a company to use efficiently its resources, ROA takes into consideration the debt of the company since total assets include the capital borrowed. On the other hand, ROE does not take into consideration how leveraged a company

is, since it only measures the return on the company's shareholders' equity, depicting, therefore, the firm's capability of producing profit from the invested equity in the company.

Earnings per Share is computed by dividing the company's profit by its outstanding common shares (See Equation 3). EPS is a good ratio for assessing the corporate value of a company by estimating the amount of money a company makes for each share of its stock (Fernando, 2022).

$$EPS = \frac{\text{Net Income} - \text{Preferred Dividends}}{\text{End of Period Common Shares Outstanding}} \quad (3)$$

Gross Profit Margin is conveyed as the percentage of revenue that the firm keeps as profit, by removing direct costs to the revenues (See Equation 4). This metric is useful for understanding the financial health, management skills, and growth potential of a firm (Segal, 2021).

$$GPM = \frac{\text{Gross Profit}}{\text{Revenue}} \times 100 \quad (4)$$

According to McGahan and Porter (2002), ROA is the most widely used measure of accounting profitability and the most used in the variance of profitability research literature (e.g., Bamiatzi et al., 2016; Bayazidi et al., 2016; Behbahaniinia & Golbidi, 2022; Etiennot et al., 2019; Flammer & Ioannou, 2021; Guo, 2017; Goddard et al., 2005; Karniouchina et al., 2013; Ketelhöhn & Quintanilla, 2012; Lim & Rokhim, 2021; Mauri & Michaels, 1998; McGahan & Porter, 2002; Short et al., 2007; Yazdanfar, 2013). Therefore, since ROA is considered the most adequate measure for this line of work because it depicts the actual position of the companies analysed, this study will also use the ROA ratio as a profitability measure and, therefore, a proxy for the dependent variable. Moreover, for reasons of interpretability and comparability of results obtained, ROA will be used to maintain consistency with past literature so that direct comparisons may be feasible, and, in the future, accurate and generalized conclusions can be drawn.

Nevertheless, according to Short et al. (2007), relying only on ROA can understate the importance of the studied effects on a firm's profitability. Bamiatzi et al. (2016) also suggested that, for the sake of future research, alternative forms for accounting firms' performance could be helpful to confirm the results obtained so far. Moreover, other authors (e.g., Alarussi & Alhaderi, 2018; Lim & Rokhim, 2021) have used ROE and EPS in their studies and

Stavropoulos et al. (2015) mentioned other accounting indicators that have been used, to a smaller extent, to evaluate a firm's performance, such as PM, ROIC, and ROS.

Therefore, this study will also use other forms of accounting profitability measures, namely, ROE, EPS, and GPM as proxies for studying the dependent variable.

ROE and EPS were selected taking into account the number of studies that used or suggested the use of these measures. According to Lim and Rokhim (2021), ROE has the benefit of depicting the firm's capability of producing profit from the invested equity in the company. Whereas Gross Margin (%) was selected to avoid biased comparisons between global companies. For instance, the USA considers R&D expenses as an intangible asset, that is, it is completely amortized while Europeans normally consider only research as an intangible asset, being the development expenses considered as an expense, which may lead to the comparison of different results and reaching misleading conclusions. Therefore, comparisons of companies, using results before amortization and depreciation, are immune to the differences in accounting practices of each country. Hence the reason why it is better to use Gross Margin over EBIT as a measure of profitability.

This study will use four different profitability measurements, maximizing the potential of these measures, and minimizing their individual limitations. By using more than one indicator to measure profitability, this study is expected to draw conclusions, regardless of the indicator used as a proxy, on the influence of the independent variables on these firms' profitability.

3.1.3. Independent variables

This dissertation focuses on firm-level profitability determinants and studies critical factors that may influence the profitability of firms within the pharmaceutical and biotechnology sector, namely firm size, firm leverage, R&D investment, the impact of the COVID-19 pandemic, and the development of COVID-19 vaccines and COVID-19 treatments.

According to Stavropoulos et al. (2015), the number of independent variables included in this type of analysis has increased over time and many authors have used firm size as a variable to study the firm's profitability (e.g., Alarussi & Alhaderi, 2018; Goddard et al., 2005; Lim & Rokhim, 2021; Short et al., 2007; Yazdanfar, 2013). Also, many have studied the impact of leverage on the firm's profitability (e.g., Alarussi & Alhaderi, 2018; Bayazidi et al., 2016; Flammer & Ioannou, 2021; Goddard et al., 2005). Since this study ought to analyse the profitability of companies within the pharmaceutical and biotechnology sector it's only natural to also study the R&D influence on the firm's profitability. Indeed, many authors used R&D as a variable to study a firm's profitability (e.g., Bayazidi et al., 2016; Flammer & Ioannou, 2021;

Short et al., 2007). Moreover, to answer the questions enumerated previously the COVID-19 impact (e.g., Behbahaninia & Golbidi, 2022) and related developed products, should be explored in the present study.

Firm Size

According to the RBV the bigger the size of the firm the better the access to resources that would lead to increased profitability (e.g., Alarussi & Alhaderi, 2018; Lim & Rokhim, 2021; Yazdanfar, 2013). Lim and Rokhim (2021) results indicated a positive relationship with profitability as measured by ROA and ROE, however, a negative relationship when the measure of profitability used was EPS. Moreover, as suggested by Goddard et al. (2005), a positive relationship between size and profit is expected if firms gain advantages from scale or scope economies as they grow. Nevertheless, the size-profit relationship can be negative if growth tends to lead to diseconomies of scale (Goddard et al., 2005). In their study, Goddard et al. (2005) found evidence of a negative relationship between firm size and profitability (ROA used as measurement).

Taking into consideration that this study analyses pharmaceutical and biotechnology companies that intend to reach a great number of people globally, it is expected, therefore, a positive relationship between firm size and profitability.

To measure a firm's size, one may use several proxies such as total assets, sales, and employees, as suggested by Alarussi and Alhaderi (2018), Bain (1951), Flammer and Ioannou (2021), Goddard et al. (2005), Lim and Rokhim (2021), Short et al. (2007), and Yazdanfar (2013). From the preliminary analysis results the firm's size measured as per total number of employees was excluded due to the lack of statistical significance found. Therefore, for this study and taking into consideration the database used and the preliminary results, the firm size will be depicted by the firm's volume of revenues (size_rev). Moreover, this variable will be converted into the natural logarithm form to improve the model fit as per literature (e.g., Alarussi & Alhaderi, 2018; Lim & Rokhim, 2021; Short et al., 2007; Yazdanfar, 2013).

Firm Leverage

As previously mentioned, several studies have tried to establish a relationship between a company's specific internal determinants and its profitability. One of those determinants studied is the firm's leverage (e.g., Alarussi & Alhaderi, 2018; Bayazidi et al., 2016; Flammer & Ioannou, 2021; Goddard et al., 2005). The firm leverage is a ratio that intends to measure a

company's level of debt and, lastly, assesses the ability of a company to meet its financial obligations (Hayes, 2020). Firms with higher leverage should be riskier to invest in because the difficulty of meeting their obligations is higher and it lowers the profit (Hayes, 2023). It is expected, therefore, a negative relationship between firm leverage and profitability (e.g., Alarussi & Alhaderi, 2018; Bayazidi et al., 2016; Flammer & Ioannou, 2021; Goddard et al., 2005).

Typically, firm leverage ratios tend to be in the form of debt-to-equity, debt-to-assets, or an equity multiplier (Assets-to-Equity). The total-debt-to-total-assets leverage ratio has the advantage that it can be used to compare the leverage of different companies in the same industry (Hayes, 2023). Alarussi and Alhaderi (2018) used the debt-to-equity ratio as a measurement of the firm's leverage, whereas many authors defended the use of the debt-to-assets ratio to study the firms leverage (e.g., Bayazidi et al., 2016; Behbahaninia & Golbidi, 2022; Flammer & Ioannou, 2021).

From the preliminary analysis results the firm's leverage measured as per debt-to-assets was excluded due to the lack of statistical significance found. Therefore, taking into account the results of the preliminary analysis and also to maintain consistency, this study will use the ratio of Debt-to-Equity as a measure of firm leverage (lev_TDtoTE), as computed in Equation 5.

$$Debt\ to\ Equity = \frac{Total\ Debt}{Total\ Equity} \quad (5)$$

R&D Investment

Since the pharmaceutical industry and biotechnology sector are highly dependent on R&D it is expected a positive relationship between R&D and these firms' profitability. That is, the more firms invest in R&D the higher the profits these companies make since they are able to produce new sources of income.

Behbahaninia and Golbidi (2022) studied the influence of R&D on profitability during the COVID-19 pandemic and were able to demonstrate a positive relationship between R&D investments and the firms' overall performance, as measured by ROA and ROE. However, Bayazidi et al. (2016) studied the influence of R&D on the profitability of pharmaceutical companies and did not find a significant influence of this determinant on the profitability measured as ROA. Moreover, Tušek et al. (2021) concluded that R&D expenses have a negative impact on the profitability of pharmaceutical and biotechnology companies. According to them, this might be the result of the accounting foundation since higher R&D expenses have a

negative impact on the bottom line of the companies (since expenses are subtracted from the profit) or its effect may be lagged on the resulting profitability. One should take into consideration that not all innovations produced by R&D investments get to be commercialized, but the expenses to develop these innovations have an impact on the profitability of these companies, which may lead to negative profitability.

According to the methodology of Flammer and Ioannou (2021) research, a ratio of R&D expenses to total assets should be a good measurement of R&D. Whereas Short et al. (2007) computed R&D by dividing the R&D expenditure with the total sales of the company. From the preliminary results and also to maintain consistency with past research, this study will use a relation of R&D to total assets (rd_assets) as computed by Flammer and Ioannou (2021) (see Equation 6).

$$R\&D = \frac{R\&D\ Expenses}{Total\ Assets} \quad (6)$$

COVID-19 Impact, Vaccine and Treatment

Since one of the questions to be studied is the impact of the COVID-19 pandemic on the profitability of pharmaceutical companies, a dummy variable (indicator or explanatory variable) had to be used to represent this qualitative variable in the regression analysis. A dummy variable is useful to represent a value of a categorical variable and, therefore, include it in an analysis that, otherwise, would not be possible to perform. This variable assumes values of 0 or 1 to indicate the absence or presence of some characteristic. Therefore, three dummy variables were created.

The first dummy variable (covid) was created to measure the effects of the COVID-19 pandemic on the profitability of these companies. If the data collected was related to the post-pandemic period (the year 2020 and forward), then the variable would assume a value of 1, otherwise the value of 0 was given. A specific column for this variable was inserted into the data Excel file extracted. According to Behbahaninia and Golbidi (2022), it is expected that COVID-19 will have a negative impact on the profitability of these companies.

The second dummy variable (covid_vac) analyses the development of the COVID-19 vaccine's influence on these companies' profitability. Companies that have developed the vaccines will assume a value of 1 and the companies that did not develop a COVID-19 vaccine will assume a value of 0. Thus, a list of companies that developed a COVID-19 vaccine was extracted from WHO and the details can be further seen in Table I. As a result, a column for this dummy variable was inserted into the data Excel file extracted. It is expected a positive

relationship between the development of the COVID-19 vaccine and the profitability of these pharmaceutical companies.

Table I. COVID-19 vaccines approved by WHO

Vaccine	Pharmaceutical Company	Biotechnology Company	Date of Emergency use listing by WHO
Comirnaty	Pfizer	BioNTech	31 December 2020
Covishield (AZD1222)	AstraZeneca	-	16 February 2021
Janssen/Ad26.COV 2.S	Johnson & Johnson	-	12 March 2021
mRNA 1273	-	Moderna	30 April 2021
-	Sinopharm	-	7 May 2021
CoronaVac	Sinovac Biotech	-	1 June 2021
Covaxin (BBV152)	Bharat Biotech	-	3 November 2021
Covovax (NVX-CoV2373)	-	Novavax	17 December 2021
Nuvaxovid (NVX-CoV2373)	-	Novavax	20 December 2021

Source: Adapted from WHO (2022)

Finally, the third dummy variable (covid_treat) analyses the development of the COVID-19 treatment's influence on these companies' profitability. Hence, companies that have developed COVID-19 treatments will assume a value of 1 and the companies that did not develop a COVID-19 treatment will assume a value of 0. Thus, a list of companies that developed a COVID-19 treatment was extracted from WHO and the details can be further seen in Table II. As a result, a column for this dummy variable was inserted into the data Excel file extracted. It is expected a positive relationship between the development of the COVID-19 vaccine and the profitability of these pharmaceutical companies.

Table II. COVID-19 treatments approved by WHO

Medicine/API	Pharmaceutical Company	Date of Publication	Date of Prequalification
Dexamethasone	FarmaK JSC	10 July 2020	05 November 2020
Nirmatrelvir + Ritonavir	Pfizer	17 December 2021	22 April 2022
Remdesivir	Gilead	29 March 2022	25 April 2022
Tocilizumab	Roche Products Ltd	19 May 2021	10 February 2022
Molnupiravir	Divi Laboratories Ltd	16 November 2021	29 September 2022

Source: Adapted from WHO (2022)

To conclude, a summary of the variables analysed is presented in the following table (see Table III).

Table III. Variables Analysed in the Model

	Variables	Measurements	Effect Forecast	Supported Studies
Dependent Variables	Profitability	Return on Assets (ROA)	N/A ²	N/A
		Return on Equity (ROE)	N/A	N/A
		Earnings per Share (EPS)	N/A	N/A
		Gross Profit Margin (GPM)	N/A	N/A
Independent Variables	Firm Size (size_rev)	Log of Total Revenues	+	Yazdanfar (2013) Alarussi & Alhaderi (2018) Lim & Rokhim (2021)
	Firm Leverage (lev_TDtoTE)	Debt-to-Equity	-	Goddard et al. (2005) Bayazidi et al. (2016) Alarussi & Alhaderi (2018)
	R&D investments (rd_assets)	Ratio between R&D expenditure and total assets	Indeterminate	Bayazidi et al. (2016) Tušek et al. (2021) Behbahaninia & Golbidi (2022)
	COVID-19 (covid)	Dummy Variable	-	Behbahaninia & Golbidi (2022)
	COVID-19 Vaccine (covid_vac)	Dummy Variable	+	N/A
	COVID-19 Treatment (covid_treat)	Dummy Variable	+	N/A

Source: Elaborated with information extracted from the research papers presented

3.2. Conceptual Framework

The prepared database has two dimensions, company numerical identifier with $i = 1, (\dots), I$, $I=1622$ and year with $t=1, (\dots), T$, $T=10$. As previously mentioned, data with both cross-sectional (i) and time-series (t) dimensions are considered panel data (longitudinal data). Regarding panel data, the determinants of profitability are tested with the initial statistical model described in Equation 7, assuming linearity between independent variables, and using

² N/A – Not Applicable

PLM regression, with random effects estimation techniques and adjusting for heteroskedasticity-consistent (HC) standard errors, as per literature (Clark & Linzer, 2015). The dependent variable of profitability is going to be studied with proxies ROA, ROE, EPS, and GPM as per literature standard profitability measures, and the independent variables are those presented and described in the model as follows.

$$\begin{aligned} Profitability_{i,t} = & \alpha_t + \beta_1 Firm\ Size_{i,t} + \beta_2 Firm\ Leverage_{i,t} + \\ & \beta_3 Firm\ Location_{i,t} + \beta_4 R\&D\ investments_{i,t} + \beta_5 Firm\ COVID19_{i,t} + \\ & \beta_6 Firm\ COVID19\ Vaccine_{i,t} + \beta_7 Firm\ COVID19\ Treatment_{i,t} + \varepsilon_{i,t} \end{aligned} \quad (7)$$

Where α_t is a constant and has a constant partial effect over time, Firm Size (size_rev) is the natural logarithm of total sales of firm i at time t, Firm Location (loc) is a dummy variable of the continents headquarters of firm i at time t, Firm Leverage (lev_TDtoTE) is a ratio between total debt to total equity of firm I at time t, R&D investments (rd_assets) is a ratio between R&D expenditure and total assets of firm i at time t, Firm COVID-19 (covid) is a dummy variable if the data is related to the COVID-19 pandemic of firm i at time t, Firm COVID-19 vaccine (covid_vac) is a dummy variable of the manufacturing of COVID-19 vaccines of firm i at time t, Firm COVID-19 treatment (covid_treat) is a dummy variable of the manufacturing of COVID-19 antiviral medicines of firm i at time t, and ε the error term that represents idiosyncratic errors or disturbances (changes in both i and t). Being that this model was estimated four times with four different measurements of profitability (ROA, ROE, EPS and GPM).

To synthesize, the initial conceptual framework is represented in the following figure (see Figure 3.1).

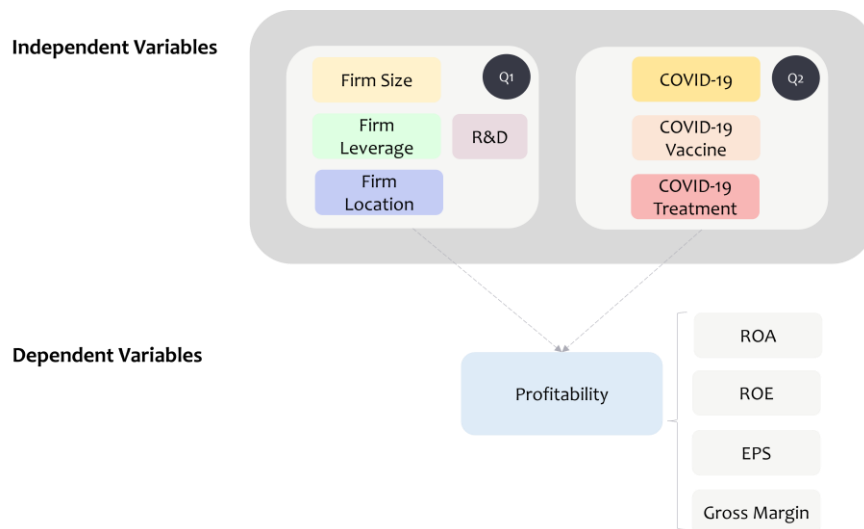


Figure 3.1. Initial Conceptual Framework

3.3. Data Analysis

In the scope of the analysis, *Microsoft Excel*®, *R*® and *RStudio Statistics*® software were utilized. First, *Microsoft Excel*® was used to clean the data, select the variables, and format the data to work with *RStudio*®. Then, the descriptive analysis, correlation analysis, regression analysis, and validation of the models and assumptions were made exclusively using *RStudio*®. *RStudio*® is an integrated development environment for *R*®, a programming language for developing graphs, plots, and statistical calculations.

First, descriptive analysis was used to summarize the data set to interpret the mean, median, and standard deviation of the variables previously selected. Moreover, the assumptions to perform the regression analysis, namely the linearity, exogeneity, absence of collinearity, homoskedasticity, and normality of residuals, were tested.

Then, correlation analysis and multiple linear regression were performed to understand the relationship between the variables. While correlation analysis shows how a variable behaves with the increase or decrease of other variables, with regression analysis we are able to quantify this relationship. For both, the Pearson method was used.

A correlation analysis and matrix were created to check how the different variables are correlated with each other and describe the strength of that correlation. This correlation coefficient can range from -1 (perfect negative correlation) to 1 (perfect positive correlation).

The regression analysis was performed and the coefficients of determination, R^2 and Adjusted R^2 , were calculated. The coefficient of determination is a statistical measure in a regression model that determines the part of the variance in the dependent variable that can be explained by the independent variable, that is, R^2 is the percentage of the sample variation in the dependent variable explained by the regression (explanatory variables). For instance, if the R^2 is 0,7 it means that 70% of the total variation on the dependent variable is explained by the variation of the explanatory variables. The remaining 30% represents the part of the variance of the dependent variable that cannot be explained nor eliminated by the model. The Adjusted R^2 is the R^2 adjusted to the usage of multiple explanatory variables. Adding more independent variables to the model will always result in an increase of the R^2 , even if artificially (they might not directly influence the dependent variable). The Adjusted R^2 considers the variances instead of the variations which penalizes the number of explanatory variables used. Therefore, the Adjusted R^2 imposes a penalty to the original R^2 depending on the number of explanatory variables used in the model. Thus, to analyze a multiple regression model the focus should be on the Adjusted R^2 . The coefficient of determination can range between 0 and 1, with 1 being

the perfect *Goodness of Fit of the Model*, and with a result of 0 the conclusion is that there is no relation between variables. Therefore, the higher the Adjusted R^2 the better the model. Moreover, to treat panel data there are two widely used approaches to perform the multiple regression, namely the fixed effects (FE), and the random effects (RE) methods (Clark & Linzer, 2015). According to Clark and Linzer (2015), random effects are usually more efficient than fixed effects. To choose between those methods the Hausman Test was performed, as per the literature (e.g., Qin & Al Amin, 2023). If the p-value of the test is significant (threshold of 0,01) then it is advisable to use FE, otherwise, the RE should be used. According to the results obtained from this test (Table VI), regressions (8), (9) and (11) should be modelled with random effects estimators, whereas regression (10) should be modelled with the fixed effects approach. However, according to Clark and Linzer (2015), the Hausman test results may not be sufficient for deciding between both approaches. According to them, what should be taken into account to choosing between approaches, are the size of the dataset, the level of correlation between the covariate and unit effects, the extent of within-unit variation in the independent to the dependent variables, and the goal of the modelling exercise. For them, the final decision should revolve around the bias-variance trading-off. Their results suggest that although the random effects estimator may yield biased estimates, it is also expected to reduce the sample-to-sample variation in those estimates, and therefore, does not necessarily justify preferring the fixed effects estimator. Thus, for interpretability and comparability of the results obtained, in this study, the random effects estimators were used throughout all the regressions.

All the results from these analyses are going to be further presented in the following section of the Data Presentation and Results Discussion.

CHAPTER 4

Data Presentation and Results Discussion

4.1. Descriptive Statistics

As previously mentioned, to have a better understanding of the data used descriptive statistic tools, such as measures of location and dispersion to compute, and graphics (correlation matrix) to represent the data, were performed.

The results obtained from the descriptive statistics are described in Table IV. The sample includes 1622 companies in the period of 2012 to 2021.

Table IV. Summary of the Descriptive Statistics Results

	<i>Observations</i>	<i>Average</i>	<i>Median</i>	<i>SD</i>	<i>Min.</i>	<i>Max.</i>
Dependent						
ROA	12410	-1,25	0,01	58,20	-6199,14	44,85
ROE	11456	-0,73	0,03	9,82	-650,60	6,36
EPS	6238	-586,33	0,01	31703,87	-2400000,0	4800,0
GPM	10203	11,10	0,49	1195,48	-6067,33	120592,0
Independent						
Firm Size (<i>size_rev</i>)	11892	17,05	17,41	2,89	-0,16	26,30
Firm Leverage (<i>lev_TDtoTE</i>)	9272	1,03	0,25	11,83	-0,21	773,87
R&D (<i>rd_assets</i>)	9350	0,29	0,06	1,68	-0,49	91,21
Where: <i>size_rev</i> is computed by the natural logarithm of total revenues; <i>lev_TDtoTE</i> is the ratio between total debt to total equity; <i>rd_assets</i> is a ratio between R&D expenses and total assets.						

Source: Author Compilation

From the results presented in Table IV, the average of the dependent variables measuring the firm's profitability of these firms are negative with the exception of GPM which has an average of 11,10 and varies by 1195,48 standard deviations. ROA, ROE and EPS have averages of -1,25, -0,73 and -586,33, respectively. The results demonstrate the presence of a high fluctuation of these financial performance measures since they have high standard deviations and large gaps between the minimum and maximum values. The minimum and maximum values of the dependent variables tend to be very high, in absolute terms, denoting the presence of outliers. Outliers of the measures of profitability of firms within the pharmaceutical industry may be common. This industry, which is highly dependent on the development and entry

regulations of new products, may incur large expenses without, however, having revenues to accompany these same expenses. Hence, the values of profitability in some companies may be so discrepant. For instance, a new company in the market that has yet to introduce its products into the market is registering large expenses without revenues, and, therefore, having highly negative margins. Analyzing the median values, the profitability, as measured by ROA, ROE, EPS, and GPM, tends to be positive. From these results, ROA and ROE seem to be better measurements to study the profitability of these firms since they present lower standard deviation values and lower absolute minimum and maximum values, which in turn, will lead to better results of the coefficients of determination.

In terms of the independent variables, Firm Size has an average of 17,05 and varies by 2,89 standard deviations. The firms within this study seem to be very leveraged since this variable has an average of 1,03 and varies by 11,83 standard deviations. Moreover, these firms have an average of 0,29 R&D investments that can vary by 1,68 standard deviations.

4.2. Correlation Analysis

The correlation analysis was done using the Pearson method since it's the appropriate method for quantitative continuous variables that are normally distributed and have a linear relationship, as in this case (Soetewey, 2020). The results from this analysis can be seen in Table V.

Table V. Correlation Analysis between dependent and independent variables

	ROA	ROE	size_rev	lev_TDtoTE	rd_assets	covid_vac	covid_treat	covid
ROA	1							
ROE	0.46***	1						
size_rev	0.55***	0.24***	1					
lev_TDtoTE	-0.10***	-0.15***	-0.04**	1				
rd_assets	-0.56***	-0.28***	-0.44***	0.09***	1			
covid_vac	0.04***	0.01	0.04**	-0.00	0.01	1		
covid_treat	0.02	0.01	0.02	-0.00	-0.01	-0.00	1	
covid	-0.06***	-0.03*	-0.06***	-0.01	0.03*	0.04***	0.03*	1

Computed correlation used Pearson-method with listwise-deletion.

*Correlations in bold mean significance at the 1% level. *p<0,05; **p<0,01; *** p<0,001*

Where: **size_rev** represents the firms' size and is computed by the natural logarithm of total revenues; **lev_TDtoTE** refers to the firm's leverage and is the ratio between total debt to total equity; **rd_assets** refers to the firm's R&D investments and is a ratio between R&D expenses and total assets; **covid_vac** is a dummy variable for the development of COVID-19 vaccines; **covid_treat** is the dummy variable for

the development of COVID-19 treatments; and **covid** is a dummy variable for the presence of COVID-19.

Source: Author Compilation

Moreover, the correlation matrix (Appendix C) is used as a visual aid to better overview the individual correlation coefficients between the variables.

The results from Table V and Appendix C show that, in general, the explanatory variables either exhibit a non-significant correlation or exhibit a significantly low correlation among themselves. Moreover, according to Dormann et al. (2013) only when the absolute value of the correlation coefficients between predictor variables is above 0,7 is there a potential problem of collinearity that can severely distort the model estimation and prediction. Thus, the results of this study seem to suggest that the coefficients are not large enough to present multicollinearity problems. Therefore, we can assume that the explanatory variables are independent.

Furthermore, as expected, the profitability of the pharmaceutical and biotechnology companies, as measured by ROA and ROE, is significantly correlated with almost all the variables in the study (at the level of 1%). Only the variable that portrayed the impact of the development of COVID-19 treatments showed no significant influence on the profitability measured by both ROA and ROE, and the variables that studied the impact of the COVID-19 pandemic and the development of COVID-19 vaccines showed no significant influence on the profitability measured by ROE. Regardless of the proxies used as the profitability measurement, the variables Firm Size, COVID-19 vaccine and COVID-19 treatment seem to be positively related to the profitability, whereas the variables leverage, R&D, and the COVID-19 pandemic show a negative relationship to the profitability of these companies. Nonetheless, it is important to note that this does not mean that there is a cause-and-effect relationship between these variables, just that changes in the independent variables can lead to changes in the dependent variable. Therefore, it can be predicted that when the size of these firms gets bigger, or when these firms develop a vaccine or treatment for COVID-19, these events can lead to an increase in profitability of these companies. However, when the leverage or the R&D expenses of these firms increase, then the profitability might decrease. Finally, the COVID-19 pandemic also seems to have a negative impact on the profitability of these companies, as measured by ROA.

It is also possible to conclude that the correlation between the independent and dependent variables is stronger for the proxy of profitability ROA than for ROE since the absolute values of correlation are bigger for ROA than for ROE. The strongest correlations found were firm size and R&D expenses with ROA, with values of 0,55 and -0,56, respectively.

4.3. Regression Analysis

Preliminary analysis was important to test the models and take the appropriate corrective measures to obtain good results.

The first thing to validate is the *Goodness of Fit of the Model*. As previously explained, one should check the coefficient of determination (Adjusted R^2) and validate the result. As a rule of thumb, an R^2 greater than 0,7 indicates a good fit of the model. The preliminary analysis showed different results according to the measure of profitability employed (ROA, ROE, EPS or GPM). The Adjusted R^2 was very low using EPS and GPM (lower than 0,1), so those measures of profitability were abolished, and the analysis proceeded using just ROA and ROE which had better Adjusted R^2 scores (approximately 24%, as can be observed in Table VI). Additionally, ROA and ROE were also the dependent variables that presented a higher number of observations, and, therefore, their results should be more robust.

Then, the *Global Significance Test*, in this case, the chi-squared test (χ^2 test), should be validated, that is, the p-value of the test should be below 0,01 (rejection region) for the test to be considered statistically significant.

Following, the *Individual Significance Test* (t-Test) should be validated, and the individual p-values should be below 0,01 (significance level of 1%) so the variables in the study can be considered statistically significant. Moreover, when a variable is not statistically significant, it should be eliminated so the model can be made more robust. The preliminary results showed that the firm size variable, measured with the number of employees, and the dummy variable of firm location had no statistical significance with neither the dependent variables, so they were dropped.

With the resulting data of the preliminary analysis adjustments to the model were made, and then the approach was to find the best ratios to use within firm size (as per total revenues or total assets), firm leverage (as per total equity or total assets), and R&D expenses (as per total revenues or total assets) to achieve the best explanatory model for the profitability of these companies. Therefore, from the results of the *Goodness of Fit of the Model*, the best models, which presented higher Adjusted R^2 , were the ones that used the total revenues to measure firm size, the total equity to measure leverage, and the total assets to measure the R&D expenses. The conceptual framework was therefore adjusted to its final form as represented in the following figure (see Figure 4.1). Furthermore, the results from the model using these variables are portrayed in Table VI.

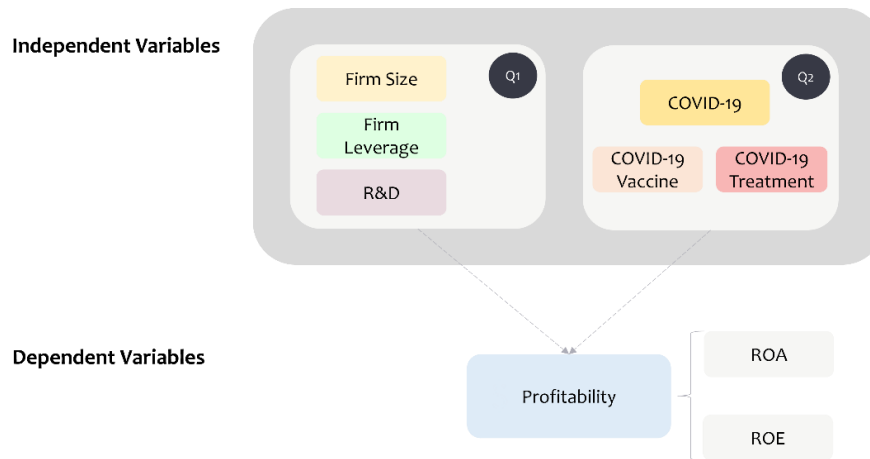


Figure 4.1. Final Conceptual Framework

4.3.1. Assumptions and model validation

To proceed with the analysis, the model assumptions had to be validated. The key assumptions in linear regression are that there is linearity between the dependent variable and the regressors, there is no correlation between the residuals, there is an absence of collinearity, there is no heteroskedasticity, and errors follow normality.

The *Breusch-Godfrey/Wooldridge* (B-G/W) test is used to analyze the correlation in panel models. The null hypothesis of this test is that there is no autocorrelation (Bobbitt, 2021). Therefore, if the p-value is lower than the threshold of 0,01 then the null hypothesis is rejected, and the conclusion is that autocorrelations exist among residuals. Taking into consideration that panel data have the time series component, finding some degree of autocorrelation is expected. From the results obtained, autocorrelation problems were found in the regressions using ROE as the dependent variable ((10) and (11)), which were considered a limitation of the model.

On the other hand, the *Studentized Breusch-Pagan* test is used to check for heteroskedasticity problems. The null hypothesis of this test is that heteroskedasticity is present in the regression (Bobbitt, 2020). Therefore, if the p-value is lower than the threshold of 0,01 then the null hypothesis is rejected, and the conclusion is that heteroskedasticity exists among residuals. From the results obtained, all regressions of the model faced heteroskedasticity problems.

Finally, the absence of collinearity is tested with the *Variance Inflation Factor* (VIF). The value for VIF starts at 1 and has no limit (Bobbitt, 2019). A value of 1 indicates that there is no correlation between a predictor variable and other variables (Bobbitt, 2019). A value between 1 and 5 indicates a moderate correlation between a given predictor and the other predictors, but no attention is required (Bobbitt, 2019). A value greater than 5 indicates a severe correlation between a predictor and other predictor variables, and the output estimates and p-values of the

regression are unreliable (Bobbitt, 2019). The results obtained showed no problems of multicollinearity since the values were all close to 1, as can be seen in Table VI.

All regressions handled heteroskedasticity and autocorrelation problems found within the data. To overcome the problems of heteroskedasticity and autocorrelation, the model was adjusted using heteroskedasticity-consistent standard errors and the *Arellano-Bond* method was applied. The output from these models can be seen in Table VI.

4.3.2. Results and discussion

As previously summarized, this dissertation consists of two parts. The first part studies the importance of firm-specific factors in the profitability of pharmaceutical companies by investigating the relation between firm size, firm location, firm leverage, and R&D with the firm's profitability in order to address question Q1. The second part addresses question Q2 by evaluating the impact of the COVID-19 pandemic and the development of COVID-19 products (both vaccines and treatments) on those firms' profitability.

Therefore, the final model had to be estimated four times. Regressions (8) (see Equation 8) and (9) (see Equation 9) used ROA as the dependent variable, whereas regressions (10) (see Equation 10) and (11) (see Equation 11) used ROE as the dependent variable to study the model. Moreover, to study the impact of the development of COVID-19 products, the dummy variables COVID-19 vaccine (covid_vac) and COVID-19 treatment (covid_treat) had to be studied separately and, therefore, the model had to be segregated into two different regressions. Thus, regressions (8) and (10) studied the impact of the development of the COVID-19 vaccines in the dependent variable, whereas regressions (9) and (11) studied the impact of the development of COVID-19 treatments in the dependent variable. Table VI presents the regression results for the panel data segregated into the four regressions performed.

$$ROA_{i,t} = \alpha_t + \beta_1 Firm\ Size_{i,t} + \beta_2 Firm\ Leverage_{i,t} + \beta_3 R\&D\ investments_{i,t} + \beta_4 Firm\ COVID19_{i,t} + \beta_5 Firm\ COVID19\ Vaccine_{i,t} + \varepsilon_{i,t} \quad (8)$$

$$ROA_{i,t} = \alpha_t + \beta_1 Firm\ Size_{i,t} + \beta_2 Firm\ Leverage_{i,t} + \beta_3 R\&D\ investments_{i,t} + \beta_4 Firm\ COVID19_{i,t} + \beta_5 Firm\ COVID19\ Treatment_{i,t} + \varepsilon_{i,t} \quad (9)$$

$$ROE_{i,t} = \alpha_t + \beta_1 Firm\ Size_{i,t} + \beta_2 Firm\ Leverage_{i,t} + \beta_3 R\&D\ investments_{i,t} + \beta_4 Firm\ COVID19_{i,t} + \beta_5 Firm\ COVID19\ Vaccine_{i,t} + \varepsilon_{i,t} \quad (10)$$

$$ROE_{i,t} = \alpha_t + \beta_1 Firm\ Size_{i,t} + \beta_2 Firm\ Leverage_{i,t} + \beta_3 R\&D\ investments_{i,t} + \beta_4 Firm\ COVID19_{i,t} + \beta_5 Firm\ COVID19\ Treatment_{i,t} + \varepsilon_{i,t} \quad (11)$$

Table VI. PLM Regression Results

	<i>Dependent Variable</i>			
	ROA		ROE	
	(8)	(9)	(10)	(11)
size_rev	0,0825*** (0,0097)	0,0831*** (0,0098)	0,0705*** (0,0113)	0,0710*** (0,0113)
lev_TDtoTE	-0,0027* (0,0013)	-0,0027* (0,0013)	-0,0233*** (0,0063)	-0,0233*** (0,0063)
rd_assets	-0,5971*** (0,0991)	-0,5954*** (0,0987)	-1,9521*** (0,3120)	-1,9508*** (0,3120)
covid	-0,0343*** (0,0097)	-0,0336*** (0,0097)	-0,0473* (0,0205)	-0,0461* (0,0206)
covid_vac	0,2876 (0,2396)	-	0,6535*** (0,0306)	-
covid_treat	-	0,0336*** (0,0095)	-	0,1079*** (0,0188)
Constant	-1,5500*** (0,1902)	-1,5614*** (0,1906)	-1,2441*** (0,2275)	-1,2536*** (0,2277)
n	605	605	503	503
Observations	4079	4079	3664	3664
R²	0,2448	0,2439	0,2376	0,2370
Adjusted R²	0,2439	0,2430	0,2366	0,2359
χ² Test	167,74***	4651,75***	116544***	1150,17***
Hausman Test	0,0242	0,0481	0,0086	0,0196
B-G/W Test	0,5453	0,6555	0,0065	0,0055
Breusch-Pagan Test	1,341e-06	1,59e-06	4,475e-15	4,71e-15
Mean VIF	1,03569	1,03267	1,07913	1,07820

Note: *p<0,05; **p<0,01; ***p<0,001
***Prob>χ² significant at 0.001

Where: **size_rev** represents the firms' size and is computed by the natural logarithm of total revenues; **lev_TDtoTE** refers to the firm's leverage and is the ratio between total debt to total equity; **rd_assets** refers to the firm's R&D investments and is a ratio between R&D expenses and total assets; **covid** is a dummy variable for the presence of COVID-19; **covid_vac** is a dummy variable for the development of COVID-19 vaccines; and **covid_treat** is the dummy variable for the development of COVID-19 treatments.

Source: Author Compilation

As previously mentioned, from the results of the preliminary analysis, firm location showed no statistical significance with any of the dependent variables studied at that point (ROA, ROE, EPS, and GPM). Therefore, it was dropped early in the investigation. One possible explanation for the lack of statistical significance of firm location in relation to profitability can, hypothetically, be explained by the fact that different regions have different fiscal legislations that can, in some way, distort the analysis and preclude the existence of a causal relationship between this variable and the dependent variable.

From the results presented in Table VI, it is possible to analyze the influence of each determinant on the profitability of pharmaceutical and biotechnology companies. The firm-specific factors that made it to the final model were firm size (size_rev), firm leverage (lev_TDtoTE), and R&D expenses (rd_assets). According to the results of the chi-square test obtained all regressions are highly statistically significant at the 1% level. Moreover, the model estimated by all regressions predicted approximately 24% of the observed variance of profitability of these companies.

Q1. What firm-specific factors have an impact on the profitability of pharmaceutical industry and biotechnology firms?

Regarding the first question of this study, the results suggest that the firm's size and the R&D investments affect the profitability of firms within the pharmaceutical and biotechnology sector, independently of the measurement used as a proxy of profitability (ROA or ROE). Furthermore, firm size has a significant positive relationship with both ROA and ROE, that is, if the firm's size increases by 1, ROA would increase by 0,08 and ROE by 0,07. Whereas the impact of the R&D expenses on the profitability seems to be negative, with a unitary increase in the R&D expenses decreasing ROA by 0,60 and ROE by 1,95. Contrary to the initial expectations that higher R&D expenses lead to the development of new products, which generate new sources of revenue and profit, higher R&D expenses seem to decrease profitability. This can be due to the fact that R&D expenses may have a lagged effect on profitability, that is, the results in the profitability of the development of new products may only be observed in the following years, confirming the results obtained by Tušek et al. (2021). This makes sense, especially considering that the sector studied is a highly regulated market in which new products go through four stages of regulation and market entry, which end up consuming a lot of time. Moreover, considering the post-COVID period, many companies may have incurred costs to develop a prevention vaccine or treatment without, however, having effectively managed to produce it, not materializing, therefore, the expenses generated. Not many companies have succeeded in developing vaccines or treatments and even fewer were

those who achieved a vaccine in the same year when the R&D investments incurred. Additionally, not all companies have decided to profit from the vaccines produced as is the case of AstraZeneca which decided to sell its vaccine at a not-for-profit price until 2021. Nevertheless, this result is under the accounting foundation, meaning that the higher the expenses to subtract from the profits, the lesser the returns, and, lastly, the profitability of the company. It can also evidence, the difficulty of dealing with the processes of managing the product's protective patents and pricing mechanisms that can lead to inefficiencies in fully making use of the previously made R&D investments. Furthermore, it is interesting to notice that leverage (as measured by debt-to-equity) is not statistically significant at the 1% level when profitability is measured by ROA. However, when the profitability is measured as ROE (regressions 10 and 11), this variable is statistically significant at the 1% level, and the estimate of the relationship is $\beta = -0,02$. This indicates a negative relationship between leverage and the performance of these companies, that is, the higher the leverage the lower the profitability of these companies (as measured by ROE). Finally, even though each explanatory variable has a different impact on profitability, it is reasonable to state that the profitability of pharmaceutical and biotechnology companies is influenced by their size, leverage, and R&D expenses. These results corroborate the results of past literature on the impact of firm-specific factors on profitability (e.g., Alarussi & Alhaderi, 2018; Bayazidi et al., 2016; Goddard et al., 2005; Lim & Rokhim, 2021; Yazdanfar, 2013).

Q2. How has the pandemic of COVID-19 affected the profitability of the pharmaceutical industry and biotechnology firms? And has the development of COVID-19 products had an impact on the profitability of these companies?

Regarding the second part of the investigation, contrary to media and public expectations that the COVID-19 pandemic resulted in a great profitability opportunity for pharmaceutical and biotechnology companies, the results seem to suggest that the pandemic has negatively impacted these firms' performance. The results of the COVID-19 variable showed to be statistically significant (at a level of 1%) with ROA, and a negative relationship was evidenced. This means that the emergence of the COVID-19 pandemic seems to have had a negative impact on the profitability of these companies. This finding followed the results of the empirical research, done so far, on the impact of the COVID-19 pandemic on the firm's profitability of listed firms (Behbahaninia & Golbidi, 2022). However, the presence of COVID-19 did not exhibit a statistically significant relationship with profitability when the dependent variable used was ROE, at the level of 1%.

However, considering the impact of the development of products for COVID-19 on the profitability of companies in the pharmaceutical and biotechnology industry, the results show, as expected, that the development of these products has had a positive effect on the profitability of the pharmaceutical and biotechnology companies since the coefficients suggest that the development of these products translate into an increase in these firms' profitability. However, this relation was only statistically significant at the 1% level, for the regressions (9), (10) and (11). When using ROA as the measure of profitability, the development of vaccines for COVID-19 seems to be non-significant as a predictor of the profitability of these companies at the level of 1%. Moreover, in the various dimensions of COVID-19 variables used, only regression (9) presented simultaneous statistical significance with both COVID-19 dummy variables studied (covid and covid_treat). Regarding regressions (9), (10) and (11), the development of COVID-19 vaccines presented an estimate of $\beta = 0,6535$ and the development of COVID-19 treatments is an explanatory factor of profitability since there was statistical significance with both dependent variables used with a β of 0,0336 for ROA and 0,1079 for ROE.

Coefficients of Determination

Focusing on the adjusted coefficients of determination, the regression that explained better the model, that is, the regression that predicted better the effects of the firm-specific factors and the COVID-19 variables on the firm's profitability was regression (8), which used ROA as the dependent variable and the impact of the COVID-19 vaccine was studied (Adjusted R^2 of 0,2439). However, none of the regressions were able to present statistical significance in all explanatory variables studied, considering a significance level of 1%. Regression (9), using ROA as the dependent variable, found significance in every independent variable except for leverage, including both COVID-19 dummy variables studied, and predicted 24,30% of profitability variance. Whereas, regression (10), using ROE as the dependent variable, found significance in every independent variable except for covid, and predicted 23,66% of profitability variance. This means that only 23,66% of profitability variance is explained by the variance in the chosen independent variables, leaving the other 76,34% of profitability variance unexplained. Therefore, other variables that were not studied could explain the variance in profitability of firms within the pharmaceutical and biotechnology companies. Other costs, such as marketing costs and other intrinsic factors such as the company's age can, potentially, have an impact on the profitability of these companies, and should be studied in further investigations.

Conclusion

Pharmaceutical and Biotechnology companies' profitability strategy is highly dependent on continuous innovation and improvement. These companies are researching new medicines to overcome new diseases on a daily basis. The first to reach a new medicine and patent it gets the chance to have a source of revenues without competition. This was the case of the COVID-19 pursuit of a vaccine and treatment. This dissertation explores the determinants of profitability of pharmaceutical and biotechnology companies under the context of the COVID-19 pandemic, covering the period from 2012 to 2021. On one hand, the relationship between internal factors, such as firm size, firm leverage, and firm R&D investments, on the firm's profitability was investigated, and on the other hand, the impact of the COVID-19 pandemic on profitability was studied and the relationship between the development of COVID-19 products in the profitability of these firms was put on evidence.

The present study is based on a large sample and uses a more reliable statistical technique than previous studies done on the profitability of pharmaceutical and biotechnology companies, strengthening the conclusions postulated. By using a rather large dataset containing information on 1622 pharmaceutical and biotechnology companies across all continents, this dissertation meets the need for further research on the profitability of this sector of activity and provides new conclusions on the determinants that have an impact on the profitability of this sector. Generally, the research made on the pharmaceutical industry has investigated factors such as R&D investment, intellectual property protection, market competition, and government regulation. This study approached the problem by combining R&D investments and alternative firm-specific determinants of profitability, investigated in other streams of research.

To conduct this study two measures of profitability were used, and the results varied slightly according to the measure of profitability employed. For instance, the development of COVID-19 vaccines seems to be non-significant as a predictor of the profitability of these companies, as measured by ROA. However, using ROE significant positive evidence of this relationship was found. This means that the significance of the independent variables may be due to the choice of the dependent variable used, as in this case to measure profitability. By using more than one indicator to measure profitability, this study was able to demonstrate the statistical significance of the influence of the independent variables studied on the profitability of these companies, regardless of the indicator used as a proxy.

Despite the model's failure to fully explain the variation of profitability since the independent variables chosen were able to explain only between 23,59% and 24,39% of the profitability variance, this dissertation provided a new understanding of the topic by providing new empirical evidence on a matter that was not yet particularly researched in past studies. Therefore, this dissertation is the first step to a better understanding of how the profitability of pharmaceutical and biotechnology companies is affected and offers a promising opportunity for future research regarding the profitability of this sector of activity.

What Determinant Factors regulate the profitability of the sector?

From the results of this dissertation, it is possible to conclude that the size of the firm, the leverage degree, and the R&D investments do have an impact on the firm's profitability. Firm size seems to positively influence profitability, whereas leverage and R&D investments seem to hurt the pharmaceutical and biotechnology companies' profitability. The results obtained of the firm's size and leverage are in agreement with past investigations (e.g., Alarussi & Alhaderi, 2018; Bayazidi et al., 2016; Lim & Rokhim, 2021; Yazdanfar, 2013). Nonetheless, the results obtained from R&D investments are contrary to the expectations that the higher the investment in R&D, the higher the profitability of these firms (e.g., Behbahaninia & Golbidi, 2022). Moreover, it is important to recall that these variables do not fully predict the model. Therefore, this investigation can be improved if other variables were to be studied, such as marketing costs, and the company's age, or expanding this research to study external determinants such as industry- or country-specific factors that can, potentially, impact the profitability of these companies.

Indeed, Short et al. (2007) results suggested that this line of work could be improved if other factors such as industry-specific factors or strategic groups were to be studied together with the firm determinants researched in this study. Their findings suggest that to achieve superior performance not only firm determinants are important, but also the appropriateness of positioning within a strategic group and industry. On the other hand, this study could also be improved if more complex dimensions were to be studied, such as industry-by-country, industry-by-subregion, and industry-by-year effects (Stavropoulos et al., 2015).

Furthermore, the analysis of the location of the companies influence on profitability was also intended to be researched in this study. A dummy variable considering the headquarters region was assigned to each company. However, the results from this dummy variable were not statistically significant in any of the regressions, so this variable had to be given up. A suggestion for future research would be to include a variable to study how the firms' host location would impact the firm's performance.

Given the delimited objectives initially set and the limitations faced (data availability and time constraints), this study did not proceed with the suggestions made and should be seen as the starting point for this line of work. Additionally, there are still some potential research gaps in this area that could be addressed, such as combining pressing topics with research on profitability in the pharmaceutical industry. For instance, researchers could analyze the role of new technologies, such as personalized medicine, artificial intelligence, and big data, in shaping the profitability of pharmaceutical firms. Another suggestion would be to modify the present study. Instead of treating pharmaceutical and biotechnology companies altogether, making a comparison analysis of the profitability determinants of different types of pharmaceutical firms, such as large multinational corporations, generic drug manufacturers, and biotechnology startups, would be an interesting avenue. Addressing these research gaps could help to deepen our understanding of the factors that drive pharmaceutical industry profitability and decisions that impact the industry and public health more broadly. Nevertheless, the results of this dissertation are thought to have accomplished the initial objective of shedding light on the determinant factors of profitability of these companies so that internal users can make well-informed decisions, enhancing profitability and ultimately better preparing for the future.

In which way do R&D investments impact these firms' profitability?

At a more specific level, R&D investments were thought to be important for the profitability of pharmaceutical companies. The empirical findings of this study managed to disclose how these expenses impact the firm's performance and confirm that the profitability is impacted by the R&D investments made. However, contrary to the expectations that higher R&D expenses lead to higher profitability, the results of this study seem to suggest that higher R&D investments are associated with lower profitability output. This may be due to two factors, among other reasons not listed. First, R&D, although a facilitator of new sources of revenue, does not guarantee that the end products get to enter the market. As previously mentioned, the failure rate of new medicines discovery can be as high as 96% (Kanapeckaite, 2021). The risk of failure in reaching new sources of revenue, and the associated costs, may be just too high. Secondly, the accounting foundations and the lagged effects of R&D expenses should be considered. The innovations resulting from R&D usually consume a lot of time to enter the market. Therefore, there may be a gap between the time when expenses are considered and the time when revenues resulting from these expenses are generated. As R&D expenses take place, they are considered and removed from revenues, and, if the revenues do not follow the expenses increase, the resulting profitability is decreased. Thus, higher R&D expenses can, ultimately, translate into lower profitability. In this regard, the results corroborate that the growing trend

of this industry to invest in external sources of innovation to maintain sustainability rather than internal sources seems to be a more efficient way of doing business. By turning to M&A of companies with already developed new products rather than investing in R&D, pharmaceutical and biotechnology companies are able to monopolize intellectual property in a faster and cheaper fashion.

What was effectively the impact of the COVID-19 pandemic on the Pharmaceutical and Biotechnology industry's profitability?

On another note, one of the objectives of this dissertation was to evaluate the impact of the COVID-19 pandemic on the profitability of pharmaceutical and biotechnology companies. Contrary to media and public expectations that the COVID-19 pandemic directly resulted in an increase in profits for pharmaceutical and biotechnology companies, the results seem to suggest that the pandemic has negatively impacted these firms' performance (as measured by ROA). The presence of the pandemic seems to decrease ROA by 0,03. This could be possibly explained by several factors. First, the database consisted of a very heterogeneous group of companies, located in several regions of the planet, which may have influenced the results retrieved. It is known that different countries imposed different measures to tackle the COVID-19 pandemic, with some countries forcing more restrictive actions than others. This led to the lockdown policies to be felt differently around the world. In countries where greater lockdowns have been imposed, the volume of hospitalizations, even from other illnesses, was reduced. Therefore, sales of treatments for these other types of diseases may have dropped during these periods. Likewise, the companies studied may vary greatly on the type of products produced. Thus, pharmaceutical companies that are more dependent on sales of non-prescription medicines or health and wellness products may have experienced a drop in sales because demand was lower in that period. Moreover, with the COVID-19 pandemic outbreak in 2020, there was a joint effort of these companies towards the development of vaccines. These companies may have registered a great volume of R&D expenses towards the development of a vaccine or treatment without, nonetheless, being compensated by it (either because they have failed to successfully accomplish the development of these products or because the resulting revenues were just taken into consideration the following years or because the products were sold at a non-profit price). Therefore, some of the companies, especially those that produced vaccines and treatments for COVID-19, may have profited from the pandemic, but generally, according to this research results, they decreased their performance during this period.

In the last part of the study, the effect of the development of COVID-19 products' relationship with the company's profitability was studied. As expected, results suggested that

the development of these products had a significant positive impact on the firm's profitability. The development of COVID-19 treatments also suggests having a significant positive effect on ROA. Not all companies within this sector developed products to combat COVID-19, but those that took advantage of the pandemic to develop these solutions seem to have benefited from it in terms of profitability. This raises an interesting question on the dynamics between the negative impact felt by COVID-19 and how these companies managed to overcome it. In times of difficulty, the results seem to suggest that the companies that managed to come forward with a solution were the ones that had better results. These findings may seem evident, however, up until now this correlation was yet to be described. Nevertheless, one should consider a very important fact while analysing this question. The law of supply and demand. Initially, the demand for a vaccine to prevent COVID-19 was very high. However, as time went by and the world's population began to be fully vaccinated (at least in the developed countries), the demand started to decrease (Bounds & Mancini, 2023; Eaton, 2022; Quan et al., 2023; Smyth, 2022). In fact, there were even reports of spoiled vaccines because, at that time, there was a surplus of vaccines, with more vaccines being bought than necessary for administration (Eaton, 2022). Thus, it would be interesting to understand how the profitability of the pharmaceutical and biotechnology companies that developed these vaccines behaved in the following years. This study creates, therefore, an interesting avenue for future research. For instance, the period of time of future research studies could be expanded to cover the years 2022 and 2023 (the year when WHO decreed the end of the COVID-19 pandemic). Moreover, future research may focus on other nuances of the development of these products such as the impact of the usage of public funds for production.

Finally, as with all research literature, there were limitations in the development of this study that could potentially be managed differently in future investigations. Initially, the treatment and analysis of the data had constraints, and inclusion and exclusion criteria had to be applied to select the companies to be studied. First, only publicly listed companies in the pharmaceutical and biotechnology industry that had the required information related to the study available could be analysed. Then, when the data was extracted from the *Refinitiv Eikon®* platform, many fiscal years (FY) did not correspond to the calendar years. Many companies opt to have different fiscal years depending on numerous factors. This was a limitation to the statistical base since many companies have different fiscal years and cannot be compared. To surpass this limitation, the criterion adopted to define the FY from the balance sheet period end date was that if the month presented was equal to or greater than 6 months, then the year considered as the FY was the year presented. Otherwise, it would be considered FY-1. Also,

every company that had its last balance sheet period end date blank were excluded from the study. Finally, just the companies that had revenues greater than 0 in the last fiscal year were selected to proceed with the study to avoid outliers. This limited the database to 1622 companies which may seem small. One suggestion for future research is adopting other criteria to overcome the FY mismatch problem to be able to retrieve more data from more companies.

Furthermore, to study the dummy variable of COVID-19 treatments, a list of treatments was retrieved from the WHO website to pinpoint the companies that had developed treatments for COVID-19. However, this comes with its challenges since some companies listed by WHO did not appear on the database collected from the *Eikon*® platform. Companies that had developed COVID-19 treatments but did not configure the Excel listing were excluded from the analysis. Besides, some presented different information regarding the countries of headquarters in the list provided by WHO and the database retrieved from *Refinitiv Eikon*®, which made the selection process more complex, having to analyse the inclusion of this data one by one. Furthermore, the approach to analyse the production of COVID-19 diagnostic tests was also intended. However, diagnostic tests entry into the market follow different regulations according to each country's legislation and depend on numerous other factors, lacking a credible source of information, making the process of collecting global, complete, and reliable data impossible, and so this variable had to be given up. Lastly, the data retrieved showed many companies with missing data on several variables. Therefore, to proceed with the analysis the data had to be filtered to remove all the missing observations and outliers.

Another limitation of this study is the fact that the database consisted of a highly heterogeneous group of companies located sparsely around the world. Different countries have different legislations and accounting principles. For instance, the treatment of R&D investments may be different according to the location of the company. Research is usually treated as an expense, however, development can be treated as either an expense or an intangible asset, depending on the accounting standards followed. This study treated R&D regardless of the accounting standards followed. In the future, it may be wise to segregate the different accounting forms of R&D treatment to further analyse its impact on the profitability results of these companies.

Finally, autocorrelation problems were diagnosed in the regressions using ROE and all regressions faced problems of heteroskedasticity. However, these were solved by adjusting the model using HC standard errors and the Arellano-Bond method was applied.

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Appendices

Appendix A Summarizing Table of the Literature Review

Research	Period	Sample	Statistical Technique	Dependent Variables	Independent Variables	Conclusions
Behbahania & Golbidi (2022)	2019-2020	Companies listed on the Tehran Stock Exchange	N.D. ³	ROA ROE Revenue Growth (GI)	R&D	Positive with ROA
						Positive with ROE
						Positive with GI
					COVID-19	Negative with ROA
						Negative with ROE
						Negative with GI
					R&D*COVID-19	Positive with ROA
						Positive with ROE
						Positive with GI
Flammer & Ioannou (2021)	2007-2009	670 publicly-traded companies in the U.S.A	Exploratory Study	ROA Tobin's Q Firm Size Leverage Liquidity	Workforce Capital Expenditures R&D	Companies which curtailed their workforce and capital expenditures, while maintaining their R&D and CSR investments performed better during and post-crisis
					CSR	
Lim & Rokhim (2021)	2014-2018	10 pharmaceutical listed companies in Indonesia	Pooled ordinary least squares (OLS) regression using fixed-effects	ROA ROE EPS	Firm Size	Positive Inf. with ROA
						Positive Inf. with ROE
						Negative Inf. with EPS
					Assets Turnover	No Significant Influence
					Liquidity	Significant Positive Inf. with ROA
						Significant Positive Inf. with ROE
						Negative Inf. with EPS

³ Not Disclosed

Research	Period	Sample	Statistical Technique	Dependent Variables	Independent Variables	Conclusions
Alarussi & Alhaderi (2018)	2012-2014	120 companies listed on Bursa Malaysia	Pooled ordinary least squares (OLS) regression (fixed-effects panel data)	ROE EPS	Lerner Index	Positive Inf. with ROA
						Positive Inf. with ROE
						Negative Inf. with EPS
					Sales growth	No Significant Inf.
					Sustainable growth rate	Positive Inf. with ROA
						Positive Inf. with ROE
						Positive Inf. with EPS
					Firm Size	Significant Positive Inf. with ROE
						Significant Positive Inf. with EPS
					Working Capital	No Inf. with ROE
						Significant Positive Inf. with EPS
Bamiatzi et al. (2016)	2005-2011	15008 listed firms in 10 emerging and 10 developed countries	Hierarchical Linear Multilevel (HLM)	ROA	Firm-Specific	Stronger under adversity
					Industry	Weaker under adversity
					Country	Weaker under adversity
Bayazidi et al. (2016)	2001-2013	27 pharmace	Ordinary least	ROA	R&D Costs	No Significant Inf.

Research	Period	Sample	Statistical Technique	Dependent Variables	Independent Variables	Conclusions
Yazdanfar (2013)	2006-2007	12530 non-financial micro firms (4 industry sectors) in Sweden	Seemingly Unrelated Regression (SUR)	ROA	Marketing Costs	No Significant Inf.
					Number of employees	Significant Negative Inf.
					Capital-to-asset ratio	Positive Inf.
					Debt-to-asset ratio	Negative Inf.
					Firm Size	Positive Inf.
					Firm Age	Negative Inf.
					Growth	Positive Inf.
Short et al. (2007)	1991-1997 (7-Year Period)	1165 single-business firms (12 industries)	Hierarchical Linear Multilevel (HLM) and ANOVA	ROA Tobin's Q Altman's Z	Lagged Profitability	Positive Inf.
					Productivity	Positive Inf.
					Industry Affiliation	Negative Inf.
Goddard et al. (2005)	1993-2001	12 508 firms of Belgium, France, Italy, Spain and UK	Generalised method of moments (GMM) estimator	ROA	R&D; Capital Intensity; Sales; Current Ratio; Domestic Sales (%)	Firm effect is the strongest. Strategic group effect rivals the industry effect on a firm's performance
					Firm Size	Negative Inf.
					Market Share	Positive Inf.
					Gearing Ratio	Negative Inf.
McGahan & Porter (2002)	1981-1994	7793 publicly listed corporations in U.S.A	ANOVA	ROA	Liquidity	Positive Inf.
					Year	Small Portion of Variance
					Industry	Part of Variance
					Corporate-Parent	Part of Variance
					Firm-Specific	Significant portion of Variance

Source: Elaborated with information extracted from the research papers presented

Appendix B Search strategy applied in *Refinitiv Eikon®* and *Microsoft Excel®*

Selection Criterion	Selected Items	Selection Effect	No. of Rejections	Search Result
Public Listed Companies	All public listed companies in United States Dollars currency	-	-	67 812
TRBC Industry name	Inclusion of companies within the Healthcare – Pharmaceuticals & Medical Research sector	Drop off companies that are not included on this sector	64 642	3 170
Date of last financial report	Inclusion of companies that had their last financial statement available in the year 2021	Drop off companies whose last financial statement did not date 2021	1 077	2 093
Revenues	Inclusion of companies that registered revenues larger than 0 in 2021	Include only companies that were fully operational in the year of 2021	471	1 622
Sample				1622

Source: Author Compilation

Appendix C Correlation Matrix

